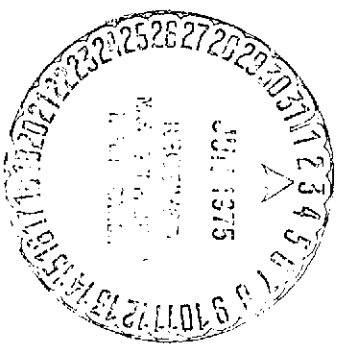
NASA TECHNICAL TRANSLATION NASA TT F-16252

IN OUTER SPACE

I. G. Borisenko

Translation of: V. Otkrytom Kosmose, Moscow, "Mashinostroyeniye" Press, 1974, pp. 1-159



(NASA-TT-F-16252) IN OUTER SPACE (Joint Publications Research Service) 126 p HC $5.75 CSCL 22A

N75-23625

Unclas
G3/12 22934

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 May 1975

STANDARD TITLE PAGE

1. Report No. NASA TT F-16252	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle IN OUTER SPACE		5. Report Date May 1975 6. Performing Organization Code
7. Author(s) I. G. Borisenko		8. Performing Organization Report No. 10. Work Unit No.
9. Performing Organization Name and Address U. S. Joint Publications Research SVC 1000 N. Glebe Road Arlington, VA 22201		11. Contract or Grant No. W13,183 13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics & Space Administration Washington, D. C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of: V. Otkrytom Kosmose, Moscow, "Mashinostroyeniye" Press, 1974, pp. 1-159

16. Abstract

17. Key Words (Selected by Author(s))	18. Distribution Statement Unclassified - Unlimited		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 125	22. Price

NASA-HQ

IN OUTER SPACE

Moscow, V OTKRYTOM KOSMOSE [In Outer Space], in Russian, 1974, pp 1-159

[Book by I. G. Borisenko, Izdatel'stvo Mashinostroyeniye, signed to press 6 August 1974, 53,000 copies]

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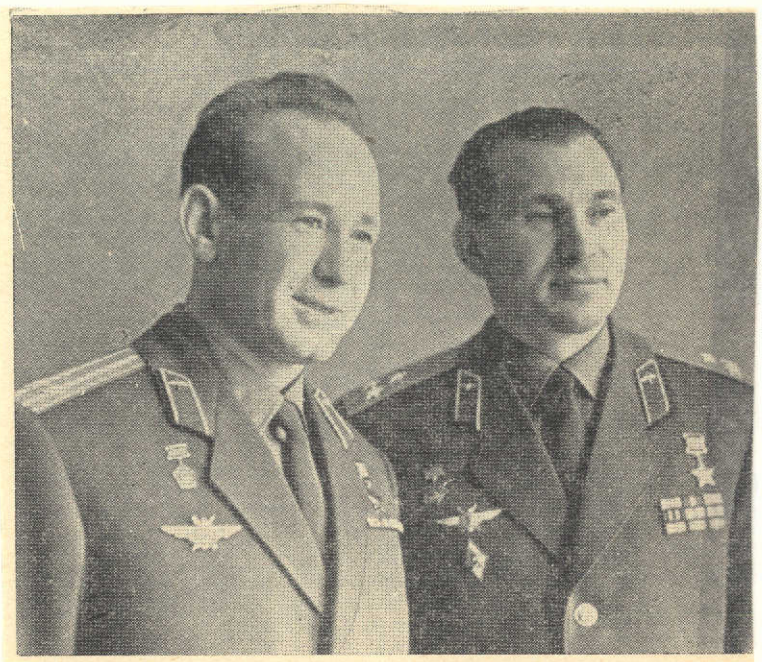

Heroes of the Soviet Union aviator-cosmonauts Aleksey Arkhipovich Leonov and Pavel Ivanovich Belyayev. A. Leonov was the first man ever to venture into open space.

ANNOTATION

[Text] The author of the book, an athletic commissar, personally witnessed all the flights of Soviet aviator-cosmonauts. He was present at the launches of the manned spaceships and met the cosmonauts at the point of landing after they completed their flights.

The story of the world's first space walk by man in outer space is told in this book, and all stages of the preparation of cosmonauts P. I. Belyayev and A. A. Leonov for this great scientific and technical experiment are described. The space walks of A. S. Yeliseyev, Ye. V. Khrunov and of American astronauts are described briefly.

The book is intended for a wide range of readers.

THE ROCKET AND SPACE

Our country paved the way for man into space. Soviet booster rockets one after the other thrust into space from the launch facilities of "Baykonur" cosmodrome artificial earth satellites, automatic interplanetary stations and manned spaceships, which successfully completed numerous sophisticated scientific-technical and biomedical experiments.

The fact that the Soviet Union carried out the first flights of artificial earth satellites, solar and lunar vehicles, automatic stations to the Moon, Venus and Mars and manned single-place and multiplace spaceships, as well as a long-term orbital station, is a source of great pride.

During this time the United States also achieved great successes in space exploration. Twelve American men landed on the lunar surface and returned to earth in "Apollo" spaceships, completing a tremendous amount of work on the exploration and analysis of our natural satellite.

The invasion of space by automatic and manned spaceships is taking place at a surprisingly fast pace. At this time England, France, Canada, Italy, Japan, China and other countries in addition to the USSR and United States, are engaged in space exploration. An extensive program of cooperation among socialist countries in space exploration for peaceful purposes, known as "Interkosmos," was developed and is being completed successfully.

More than 1,000 spaceships have been launched from the USSR, United States, England, France and other countries during the 17 years of the space age.

Man's entry into space was a brilliant accomplishment of world science and technology. Space exploration led to new discoveries in many various fields of science. The systematic exploration and conquest of near-earth space and of the planets of the solar system obviously will continue to be carried out both by manned and by automatic space vehicles.

Great importance is attached in our country to automatic vehicles for space exploration, but this does not mean that manned flights have been relegated to a secondary role in the USSR. They occupy a worthy position in the Soviet space program.

The flight of the spaceships of the "Soyuz" series and the development of the world's first orbital space station "Salyut" represented a qualitatively new stage in the development of space technology.

Man's technical capabilities are expanding exceedingly rapidly at the present time. That which yesterday seemed incredible or completely improbable has become reality today.

Much of the credit for this goes to those who developed the theoretical principles of jet propulsion, the rocket motor and jet airplane.

The first step was taken by N. I. Kibal'chich, who in 1881 designed the world's first rocket-powered vehicle for manned flight, propelled by a solid-propellant motor.

Two years later K. E. Tsiolkovskiy wrote his work "Svobodnoye Prostranstvo" (Outer Space), in which he expounded for the first time the feasibility of using a jet motor for building spaceships. In 1895 Tsiolkovskiy published in Moscow a book with the title "Grezy o Zemle i Nebe" (Dreams of the Earth and Sky), in which was propounded the idea of building an artificial earth satellite. Finally, in 1903 K. E. Tsiolkovskiy published in St. Petersburg, in the journal NAUCHNOYE OBOZRENIYE (Science Review), his classical work "Exploration of Near-Earth Space by Jet Vehicles." In that work, to which is attached great historical significance, Tsiolkovskiy lucidly and precisely presented the theoretical principles of rocket flight and described the design principles of the liquid-propellant rocket and rocket motor. The ideas which K. E. Tsiolkovskiy voiced in this remarkable work are still used in the solution of many theoretical and practical problems of space flight.

K.E. Tsiolkovskiy wrote several other works on important technical problems of rocketry and space flight. He substantiated scientifically the feasibility of man's entry into space, of colonizing interplanetary space, exploiting celestial bodies and of utilizing the energy of the sun.

Much of the credit for the development of jet propulsion theory belongs to our outstanding scientist N. Ye. Zhukovskiy, who published numerous scientific works of great practical importance on problems of flight.

Yu. V. Kondratyuk, F. A. Tsander, N. A. Rynin, V. P. Vetchinkin, V. P. Glushko, S. P. Korolev, M. K. Tikhonravov, among others, talented engineers and scientists of our country, contributed a great deal to the development of the principles of rocketry.

The Gas Dynamics Laboratory (GDL) in Leningrad and the Jet Propulsion Study Group (GIRD) in Moscow rendered invaluable service for the development of rocketry and conducted practical rocket flight tests.

Here is what Academician V. P. Glushko, eminent scientist of our country, said about the first practical efforts toward the development of rockets and rocket motors:

"...The beginning of experimental research in the USSR in the field of rocketry in accordance with K. E. Tsiolokovskiy's ideas dates back to 15 May 1929, when at my suggestion the first experimental-design organization was established at the Gas Dynamics Laboratory (GDL) in Leningrad for the purpose of developing electric and liquid-fueled rocket motors." The GDL was organized by chemical engineer N. I. Tikhomirov in 1921 under the military department.

In 1930-1931 the second department of the GDL developed and built the first Soviet liquid-propellant rocket motors, the ORM (experimental rocket motor), ORM-1 and ORM-2 under the supervision of V. P. Glushko. About 50 test firings of liquid-propellant motors were conducted in 1931. The designs of experimental motors from ORM-4 through ORM-22 were completed in 1932.

The Leningrad and Moscow Jet Propulsion Study Groups (GIRD), which united rocket enthusiasts on a public basis, were organized in the fall of 1931 under Osoaviakhim [Society for Assistance to Defense, Aviation and Chemical Construction, USSR].

The famous scientists N. A. Rynin and Ya. I. Perel'man, engineers V. V. Razumov, A. N. Shtern, Ye. Ye. Chertovskoy, V. I. Shorin and many others worked in the Leningrad group (LenGIRD), and F. A. Tsander, the great aerodynamic engineer and mathematician V. P. Vetchinkin and talented engineers S. P. Korolev, M. K. Tikhonravov, Yu. A. Pobedonostsev, B. I. Cheranovskiy, M. S. Kisenko, I. A. Merkulov and other rocketry enthusiasts worked in the Moscow group (MosGIRD). S. P. Korolev was appointed chief of MosGIRD in 1932.

Small test rockets were built in Leningrad and were subjected to flight tests. Soon GIRDs were organized in Khar'kov and other cities.

As the result of the activities of MosGIRD the first Soviet liquid-fueled test rocket of the type GIRD-09, built according to a design of M. K. Tikhonravov, was fired on 17 August 1933 at the Nakhabino test site near Moscow, and a rocket of the type GIRD-Kh, designed by F. A. Tsander, was tested the same year. Rocket 09 flew to an altitude of 400 m. The motor of this rocket developed a thrust of 25-33 kg for a period of 10 s.

In late 1933 GDL and MosGIRD were combined as the Jet Propulsion Scientific Research Institute (RNII). Within the walls of RNII worked a creative collection of Soviet rocket experts, who developed numerous experimental ballistic and winged rockets and motors for them.

During the period of 1934-1938, for example, many models of rockets, such as types 09, 10, 48, 216, 217, etc., were flown. Tests of winged rocket 212 with the ORM-65 motor were conducted in 1939. Ground tests of the RP-318 rocket plane, designed by S. P. Korolev with the ORM-65 liquid-propellant motor, were conducted in 1937-1938, and in 1940 aviator V. P. Fedorov completed the first flight in that rocket plane. In 1942

aviator G. Ya. Bakhchivandzhi completed the first flight aboard the rocket plane BI-1, developed by A. Ya. Bereznyak and A. M. Isayev under the supervision of chief designer V. F. Bolkhovitinov. The airplane was powered by the D-1-A-1100 liquid-propellant rocket motor of RNII design with a thrust of 1,100 kg.

The staff of propulsion experts who came to RNII from GDL developed from 1934 through 1938 a series of liquid-fueled rocket motors, from ORM-53 to ORM-102.

The ORM-65 motor, designed by V. P. Glushko, underwent official tests in 1936 and was the best engine of its time.

The combined efforts of the scientists and engineers of GDL, GIRD and RNII laid the foundation for Soviet rocketry.

A special commission of the USSR Academy of Sciences, in memory of the great contribution made by Soviet engineers and research organizations to the development of rocketry, named crater chains and large craters, discovered on the back side of the moon, GDL, GIRD, RNII, Korolev, Langemak, Tsander, etc.

Soviet rocket-space technology, developed by our scientists, engineers and workers, marked the beginning of the space age. Important discoveries have been made and interesting experiments and research have been conducted with the aid of this technology.

Many experiments related to the solution of scientific-technical, biomedical and national economic problems have been completed during space flights. However much remains to be done in space exploration in the interests of science and human progress.

During 17 years of active space exploration each new flight of an artificial satellite, manned spaceship or automatic space station came to be viewed as an ordinary event in our day to day lives. Today, therefore, few people are surprised by flights of manned spaceships around our planet.

When the 12 U.S. astronauts traveled to the lunar surface aboard the "Apollo" spaceships we all considered journeys by man to other planets of the solar system to be realistic. In order to complete this complex technical task it is essential from the outset to solve numerous scientific problems, on which will depend the success of mans journeys to Mars, Venus and other planets.

A great role is set aside in space exploration to automatic vehicles as the primary explorers of the universe, to be followed sooner or later by man. This is why space vehicles of the series "Luna," "Mars," "Venera," "Surveyor," "Mariner" and others, which are "conquering" the distant planets and collecting data on the composition of rocks, pressure and temperature of various layers of the atmosphere, the presence and state of magnetic poles, the level of corpuscular and solar radiation, etc., are working tirelessly this very day.

The success of manned space flights will depend to a great extent on the results of the operation of these and other space vehicles.

Speaking at a ceremonial session in the Kremlin Hall of Congresses on 12 April 1971 in honor of the 10th anniversary of Yu. A. Gagarin's flight into space and World Aviation and Cosmonautics Day, M. V. Keldysh, president of the USSR Academy of Sciences, pointed out that cosmonautics has opened extensive new opportunities to study the planets of the solar system. He emphasized that its successes are demonstrating even now that the time will come when man will make interplanetary flights. He said, however, that this is an exceedingly difficult problem, which will require many more years of hard work and the development of new aerospace technology. With each passing year, M. V. Keldysh declared in closing, the problems that modern science poses for cosmonautics are becoming increasingly complicated. More and more often it is necessary to take a combined approach to space exploration, using earth-based observation systems and various space vehicles simultaneously. Such combined studies and experiments make cooperation among scientists of various countries in the field of space exploration and mastery increasingly urgent.

"The day will come when man will venture in interplanetary space, but the feat of Yu. A. Gagarin, the first cosmonaut of our planet, Communist, charming and courageous man, will remain eternally in the memory of mankind. His flight into space was the culmination of the genius of our talented scientists, engineers, technicians and workers, the incarnation of the efforts of the Soviet people under the leadership of Lenin's great party." So spoke the president of the USSR Academy of Sciences.

We are convinced that the efforts of many countries of the world toward the systematic exploration and mastery of space already are bearing fruit and will continue to benefit mankind in the future. Consider, for example, our nearest neighbor, the moon. We already know that it is possible to build on the moon not only an astronomical observatory, but also a scientific laboratory for conducting various experiments in a vacuum and under conditions of sharp temperature changes. The moon will be the best laboratory for conducting space research. It will be possible to construct on the moon, where the force of gravity is six times weaker than that of the earth, a spaceport, from which rockets will be launched to other planets at a velocity of 2.4 km/s. A television station, built on the moon, will be able to service immediately nearly all TV viewers on the earth. It is considered possible to erect a meteorological observatory on the moon, from which observations of the cloud and snow covers of the earth, radiation of the earth, etc., will be conducted. The moon is an extremely interesting object for other studies for the benefit of mankind.

It is important that the exploration of the moon and other heavenly bodies be conducted, as declared by the Soviet government in its address to the United Nations, exclusively for the benefit of science, in the interests of peace and progress, for the benefit of all mankind. For this it is essential that each country make its own contribution to the corresponding

studies and experiments, which will promote the mastery of our planet. In this connection an international agreement on the exploration and mastery of the moon and other planets of the solar system was concluded in 1967 at the suggestion of the Soviet government. It is stated in the agreement that all governments must conduct open scientific research in accordance with the principles of cooperation and mutual assistance and in consideration of the corresponding interests of other governments for the purpose of maintaining international peace and security. Without this it is impossible to solve the basic problem, namely the use of space for peaceful purposes for the benefit of all mankind.

Automatic space vehicles, explorers of the universe, have grown beyond the limits of near-earth space and are already probing space in the vicinity of the Moon, Mars, Venus and other planets. These and other studies, of course, will continue, because the scientific attitude of scientists around the world is inexorably paving the road in this direction, surmounting all obstacles along the way.

This is why the launching to the moon and the landing upon its surface of the "Luna" and "Surveyor" automatic stations represent a great achievement by Soviet and American scientists. Some people were skeptical that the launching of automatic space stations to the moon and soft landing could ever be accomplished before 1970. But as we know, it happened much earlier. This difficult technical task was performed by the Soviet automatic station "Luna-9," which landed on the lunar surface on 3 February 1966.

This was followed in the Soviet Union by the flights of the automatic stations "Luna-16," "Luna-17," "Luna-20" and "Luna-21." The recovery vehicles of the "Luna-16" and "Luna-20" stations delivered lunar soil to the earth and the other two deposited on the moon's surface the self-propelled devices "Lunokhod-1" (1970) and "Lunokhod-2" (1973).

These days, as we see, events are actually ahead of their time.

We know that the living body experiences various factors under conditions of space flight, including weightlessness, cosmic radiation, etc. Soviet scientists launched animals into space before the first manned flights in order to study the effect of these factors on the living organism. For example, the "Kosmos-110" artificial earth satellite, carrying the experimental dogs Veterok and Ugolek, was launched on 22 February 1966. On 16 March, after the 330th orbit, the animals returned safely to earth. Scientists established that the dogs experienced an increased loss of calcium salts during the beginning of the flight and lost weight at the expense of muscle tissue and experienced some dehydration. It is known that if the human body loses 20% of its sodium chloride a convulsive state sets in immediately, and if he loses 15% water death may occur.

Scientists are interested in all phenomena that occur in the living body during extended space flights. Much work remains to be done on these and other problems related to the influence of all space flight factors on the human body.

The duration of space flights is steadily increasing. Suffice it to say that a flight to Mars and back will take about 3 years, and a journey to the nearest stars will require at least 50 years according to the best predictions. This raises many new problems for space biology and medicine. One of the basic problems in this respect is the effect of long-term periods of weightlessness on the human body during space flights.

The flights of Soviet and American astronauts have demonstrated that a comparatively brief (up to 90 days) exposure to the conditions of weightlessness is not accompanied by significant, dangerous changes in the human body. The cosmonauts all lost a few kilograms due to dehydration, and for some time during the first days on earth they experienced trouble walking and performing ordinary work. After a period of readaptation, when their bodies returned to the so-called earth state, they felt the same after the flight as they did before it.

The accelerations which an astronaut experiences during launch and re-entry have a negative influence on the body. Examples of this can be found by analyzing the flights of American astronauts F. Borman and J. Lovell in the spaceship "Gemini-7" (4-18 December 1965) and of the Soviet cosmonauts A. Nikolayev and V. Sevast'yanov in "Soyuz-9" (1-19 June 1970). In space, existing in a state of weightlessness, the cosmonauts felt that the heart worked under less stress and they experienced strong flow of blood to the head. Meanwhile scientists were suggesting that cosmonauts may experience impairments of some physiological functions during flights of longer duration.

This is why the question of the feasibility of extended space flight by man is more urgent today than ever before. In this connection the forthcoming flights by Soviet and American astronauts will be of tremendous importance for future space travels. At this very time scientists are analyzing factors that will influence human performance during space flight.

Again we are convinced how correct K. E. Tsiolkovskiy was when he said that the universe is boundless for man. Human intellect will find ways of surmounting problems as they are encountered in space flight.

However, future space flights, both in orbit around the earth and in deep space, will require powerful and modern aerospace vehicles and systems.

The perfection of aerospace technology, the development of the scientific and engineering foundation for future space exploration projects and for ever-deeper penetration by man into this mysterious and fascinating world and flights to the planets nearest to us will require a tremendous amount of preliminary work and material expenditures. For example, the cost of launching the American rocket "Saturn-1," with a payload of 9,100 kg, to an altitude of 480 km, was 1,320 dollars per kilogram of payload. For the time being, of course, the cost of sending each kilogram of payload into space will remain high.

The modern rocket motors with which spaceships are equipped operate basically on liquid propellant, which adds greatly to the weight of the rockets and is rapidly consumed. Flights to the distant planets of the solar system will require powerful engines that use more efficient energy sources. Scientists favor nuclear engines, but this will require the solution of many more engineering problems.

Some scientists express the opinion that flights to stars will require the use of photon rocket engines, which produce thrust by ejecting a beam of light, i.e., photon. Other scientists assert that future star flights will require rockets with ion engines, in which fuel particles (vapors of readily ionized metals) lose electrons in the ionizer and are accelerated to a high velocity in an electric field.

Some experts say that future rocket engines should be of the electric or plasma type. There have been suggestions that solar engines, or engines that use the energy of cosmic radiation, be used in rocket systems.

Flight velocities are of tremendous importance in the solution of problems related to man's penetration into space, not only in satellite ships, but in other space vehicles as well. Today modern jet airplanes fly at speeds in excess of 3,000 km/hr. Research has demonstrated that even at this speed the skin of an airplane is heated to 300°C, which is harmful not only to the airframe, but for engine operation as well. This "thermal barrier" seemed to be insurmountable and nearly impossible to solve, but such is not the case. The first thing to do to overcome the "thermal barrier" was to increase flight altitude. Then, because of the low density of air in the upper layers of the atmosphere and thermal radiation from the skin of the airplane, the temperature becomes acceptable for an airplane flying at such velocity.

In June of 1962, for example, the American aviator R. White, after being released at high altitude from a bomber aboard the rocket-powered X-15 aircraft, reached an altitude of 96 km. This plane attained a velocity of about 7,000 km/hr.

Consequently man can travel into space aboard vehicles other than satellites. Designers are suggesting the development of a manned vehicle capable of taking off from the earth like an airplane, flying into orbit, descending from orbit and landing at a selected air field.

Such a vehicle, according to designers and scientists, should be called an aerospace plane. There are many proposals concerning the development of a vehicle with wings that can be folded away during flight into space and during orbital flight in order to reduce dynamic drag, and of being extended again during re-entry into the dense layers of the atmosphere for descent and landing. This, of course, is a complex adaptation for such vehicles, but they nevertheless should find application in the future. The value of such a vehicle is the fact that the design provides an opportunity to "control" speed with lifting surfaces.

A rocket plane with hydrogen-fueled jet engines, capable of flying at speeds 6-8 times faster than the speed of sound, has been proposed as one such hypersonic vehicles.

And so the development of aerospace vehicles that can be maneuvered and landed at any air field in any region has become an urgent problem.

When attempting to see into the more or less distant future of aviation and astronautics one must not forget the problem of the relationship between man and the flying machine. In spite of the rapid development of automated systems and instruments, man will fly and control the flight of his own ship, no matter how complicated the flight is.

Until now we have been discussing basically scientific problems of astronautics associated with the use of aerospace vehicles for manned flight into space, flights of automatic space vehicles for scientific purposes, for exploration of the other planets and processes that take place within the depths of the universe.

Let us now talk about what must be done in order to exploit space for the benefit of mankind.

First of all, man is interested in problems of using rockets and spaceships for transporting passengers, freight, mail, etc. In an interview with TASS correspondent A. P. Romanov[1], Academician S. P. Korolev, designer of the first space rocket systems, said the following on this subject: "...First of all, spaceships will be a great means of transportation... The trip from Moscow to New York, including launch and landing, will take only 1.5-2 hours instead of 11. They will be capable of hauling mail, freight and, of course, passengers..."

When asked about the problem of weightlessness, S. P. Korolev replied, "This is one of the most important problems to be solved. The fate of all space travel depends upon its successful solution. The effect of weightlessness on the human body is by no means completely analyzed. Perhaps we will be able to create temporary 'artificial gravity' in spaceships. Perhaps such a measure will reward us greatly...".

In the space exploration program of our country, as we have already mentioned, great importance is attached not only to automatic systems, but to manned spaceships as well. Scientists affirm that in order to achieve the most effective mastery of near-earth space it is advisable to develop first small, and then large extended orbital stations of more complex design, manned by large crews. The crews should be made up of experts in various occupations to permit the combined solution of many scientific-technical, biomedical and national economic problems. Extensive use will be made of space transport ships, which will make trips by an earth-station-

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[1]A. P. Romanov, "Konstruktor Kosmicheskikh Korabley" (Spaceship Designer), Moscow, Politizdat, 1972, 160 pages.

earth itinerary for the purposesoof replacing crew members of these stations and delivering equipment, food, fuel and miscellaneous things. Transport ships of this class may also perform the function of space rescue of crew members of spaceships and orbital stations if such a need should arise during the course of space flights, repair and restoration operations and other functions.

During extended orbital flights, moreover, they may be used for operations involving the performance testing of spaceships and other aerospace vehicles of the future. Astronauts will be able to conduct operations in open space, outside of the station or spaceship. The orbital stations of the near future will serve as test bases for the assembly, checking and testing of many aerospace systems and assemblies, and they will also perform as intermediate bases for distant interplanetary expeditions.

The development of manned orbital stations will certainly represent a new page in the history of space exploration.

Specially equipped satellites already are paying high returns in terms of weather forecasting and determination of areas in which such natural disasters as hurricanes, typhoons, floods, etc., may occur. The development of a permanent system of weather satellites will bring about the most reliable weather forecasting service.

The establishment of radio communications between the various continents, telephone and telegraph communications, television transmissions by means of one or several stationary satellites, i.e., satellites that are inserted into a so-called stationary orbit, the orbital period of which is equal to the time of rotation of the earth around its axis, represent major achievements.

Such satellites already are being used for long-distance telecommunications and television transmissions. Undoubtedly we soon will be able to watch on our television screens programs from various countries of the world, transmitted by way of communications satellites.

Analysis of the earth with the aid of satellites will produce raw material for constructing geologic forecast maps of the earth's crust, including the sea floor.

Navigation satellites will have to be used for exact determination of location on the land and water and in the air. This is especially important in cases when the crew of an airplane, ship or spaceship requires guidance. In this case they will always be able to rely on navigation satellites.

Before making a decision to send man into space the scientists always direct their attention to the status of the sun. Continuous observation of solar activity has been established for this purpose. Here also we use artificial earth satellites.

Knowledge of the laws of electromagnetic propagation is of extreme national economic importance today. The quality of radio communications, as is known, depends on wavelength and the condition of the ionosphere. In this connection it is essential to know the status of the ionosphere at various times of the day and throughout the entire year, in order to correctly forecast the propagation of radio waves on various wavelengths. Therefore analysis of the ionosphere by means of artificial earth satellites is also an important practical problem.

It may be concluded from everything said above that unlimited possibilities have been discovered for the use of artificial earth satellites, automatic and manned spaceships for the benefit of all mankind.

The following statement by K. E. Tsiolkovskiy is appropriate here:

"Progress courageously, great and small toilers of the world, in the knowledge that not a single feature of your labors will vanish inconsequentially, but eventually will bear great fruit unto you."[1]

In conclusion I should like to mention a very interesting statement on the promises of space exploration, voiced by Academician S. P. Korolev, who in early 1966 said that no branch of modern science is growing so vigorously as space exploration.

Yuriy Gagarin's flight heralded the age of space navigation. The age of man's conquest of space began in 1965, on that day in March when Aleksey Leonov stepped from the hatch into open space and maneuvered about freely in it.

The crew of the spaceship "Voskhod-2" was assigned a most difficult mission, qualitatively different from that of preceding flights. The future development of astronautics depended on the successful completion of that mission, to no lesser extent, perhaps, than on the success of the first space flight. Pavel Belyayev and Aleksey Leonov were adequate to the task, and the importance of that exploit cannot be overestimated: their flight demonstrated that man can live in open space, leave the confines of his spaceship and perform work wherever it seems necessary.

Without this capability, the scientist continued, the paving of new roads in space would be inconceivable. Indeed this was equivalent, for example, to the crew of a seagoing ship during a voyage, unable and even afraid to leave the ship.

Now, said, S. P. Korolev, we can imagine future spaceships carrying people to distant places, to the moon, planets and their satellites. The reliability of such expeditions will be increased by sending not one, but two or more ships. During the time of such a flight people undoubtedly will

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[1]K. E. Tsiolkovskiy, "Sobraniye Soch." (Collected Works), Vol II, Moscow, AN SSSR, 1954, p. 139.

be able to move from one ship to another to render assistance or to perform inspections and repairs in flight, which will substantially improve the reliability of the entire expedition. The ability to work in open space facilitates the completion of certain scientific research. We know now that modern technology makes all of this completely realistic and feasible. The flight of "Voskhod-2" proved this experimentally.

The distinguishing feature of Leonov's experiment was the fact that he entered into open space through an air lock hatch without depressurizing the entire ship. Pavel Belyayev remained in the sealed cabin under excellent conditions, maintaining communications with the earth, monitoring the progress of the flight and performing flight control operations.

Such an experimental program is uniquely correct and methodologically substantiated. This becomes obvious when one asks: why should man go out into space? The answer is simple -- to rescue a nearby ship and to work. Depressurizing the spaceship undoubtedly would interfere with all operations.

To go out into open space through a special hatch is, of course, technologically more complex and, importantly, a rather substantial weight factor must be provided for this purpose. But only this approach completely solves the problem, for the sake of which, as a matter of fact, a space walk is carried out in the first place.

The earth is encircled continuously by the orbits of numerous satellites.

Many Soviet satellites in near-earth orbits have completed a great variety of scientific research missions and continue to do so.

Modern science and technology, with their surprisingly developed automation, telecommunications and process control systems, make it possible to use automatic interplanetary stations for future flights to the moon and to the near planets of the solar system.

Difficult missions should be assigned to automatic stations, designed for soft landing, so that the station itself and all of its equipment are maintained completely intact and operational in order to carry out the prescribed program.

All of the above, fascinating plans for exploration of the universe, are steps into the future. This future, though not very near, is nevertheless realistic, since it is based on what has already been accomplished.

Each year of the space age represents a new step forward for Soviet science toward an understanding of the secrets of nature. Our great compatriot K. E. Tsiolkovskiy said: "That which is impossible today will become possible tomorrow." The entire history of astronautics verifies the validity of this statement. That which seemed inconceivable for many centuries, which only yesterday was just an idle dream, is realistic today and will be fact tomorrow.

There is no barrier to human intellect!

FLIGHT PREPARATIONS

Man's successful completion of the space exploration program aboard the "Vostok" satellites made it possible to undertake flights in the multiplace "Voskhod" spaceships.

The "Vostok" program was the foundation on which was based the development of Soviet cosmonautics. In this program six single-place manned "Vostok" satellites, with a total weight of 28,339 kg, were inserted into near-earth orbits from 1961-1963.

These ships were flown by six Soviet cosmonauts: Yu. A. Gagarin, G. S. Titov, A. G. Nikolayev, P. R. Popovich, V. F. Bykovskiy and V. V. Tereshkova, who completed 259 orbits around the earth, logged a total space flight time of 381 hours and traveled a distance of 10.5 million kilometers.

The multiplace "Voskhod" spaceship was launched on 12 October 1964 with three cosmonauts aboard: ship commander V. M. Komarov, scientist K. P. Feoktistov and physician B. B. Yegorov.

The crew of the "Voskhod" spaceship spent 1 day (24 hours 17 minutes 03 seconds) in space flight. A soft landing system was used for the first time on this flight. "Voskhod" differed substantially from "Vostok." It was not only a new, three-place spaceship, but it also had new instrumentation and numerous fundamentally new systems. Only a short time separated Yu. A. Gagarin's first flight into space and the flight of the multiplace spaceship "Voskhod." It took our scientists only a few years to solve a most difficult scientific-technical problem, related to the development of a new spaceship of the "Voskhod" type. During this time Academician S. P. Korolev, along with the engineers, designers and scientists who worked at the design office which he headed, solved many engineering problems related to the flight of "Voskhod-2" and man's venture from it into open space. At the cosmonaut training center, where the crews are trained, engineers and aviators were making preparations for future space flights.

Man's walk in open space was a qualitatively new step in space exploration.

The scientists of our country were faced with the tremendous problems of developing a new space suit, self-contained individual backpack life support system, airlock and many other engineering problems, on the solution of which depended the successful completion of this experiment. It was clear to all that man, on stepping from his ship into space, would encounter for the first time numerous factors of space flight, such as radiation, sudden temperature drops, orientation in space with no reference points, vacuum, weightlessness, the brilliance and heat of the sun, isolation and the psychophysiological state of the cosmonaut, coordination of movements, perception of time, etc.

Prior to A. A. Leonov's flight Soviet and American astronauts flew in orbits around the earth inside their spaceships. The above-mentioned and many other factors of space flight undoubtedly also had an influence on these astronauts. However, an astronaut's venture into open space outside of his spaceship, all alone in the boundless expanses of the cosmos, would impose more rigid requirements on the training of astronauts and on equipment.

This is why the entire program of special (technical), psychological and physical preparation of cosmonauts differed vastly from the preceding flight training programs for the "Vostok" and "Voskhod" crews. A. A. Leonov and P. I. Belyayev and their backups would have to undergo preparation for the forthcoming flight to guarantee the successful completion of this program.

Great attention was devoted to technical preparation. Manned spaceships, flown by aviator-astronauts, are, as is known, among the most sophisticated types of machinery. The astronauts would have to be familiar with the construction of the ship and its systems in order to learn how to control them. For this purpose they would have to undergo training under terrestrial conditions, simulating to the maximum possible extent the actual conditions the astronauts would experience in space flight.

Soviet aviator-cosmonaut A. A. Leonov says the following about such preflight preparation:

"It took place in late 1963. We studied space technology at the plant where the ships were being built. One time, when we arrived there, we were met by Sergey Pavlovich Korolev, who took us into the shop and showed us a model of the "Voskhod" spaceship, equipped with some strange chamber. Noticing our curiousity, he explained that the hatch was an exit into open space. Sergey Pavlovich asked me to put on a space suit and try to do an experiment.

"After working for 2 hours, during which I had to huff and puff quite a bit, I told Korolev what I thought. I said that in my opinion the experiment could be done, but I had to think it out better.

"'Then get to work!' declared Sergey Pavlovich, adding jokingly, 'but on

one condition: think everything out first, and if something goes wrong at the end of training don't let me catch sight of you.'"[1]

"We began to prepare for it (i.e., for the flight aboard "Voskhod-2," I. B.) long before it was built, from the moment we arrived at Zvezdnyy gorodok. Our training practically coincided with the preparation of the ship, during the time scientists and designers were working on special equipment and modification of "Voskhod." It is appropriate here to mention also the fact that while studying the design of spaceship "Voskhod-2," we solved technical problems in close cooperation with the engineers and designers. A practical checkout of completed assemblies sometimes helped to find better versions.

"And after the final design solutions were found we undertook the adoption of the entire process, of all operations associated with the space walk. We also made plans for a ship's log so that the flight would provide maximum useful information.

"Much effort was concentrated on the development of simulators to make training conditions as close as possible to actual space flight conditions. For example, we built models of the spaceship and airlock. A deep vacuum was created in the thermal vacuum chamber. And dressed in our space suits, we worked out all operations step by step.

"After mastering the necessary skills we went on to training exercises in a specially equipped Tu-104 flying laboratory, in which a brief state of weightlessness was created.

"We started painstaking work all over again. We went airborne dozens of times and during short periods of time rehearsed step by step all details of the space walk and re-entry into the spaceship.

"The gargantuan effort exerted by all the people engaged in our training cannot be expressed by words. They labored with tremendous enthusiasm, not considering, since nobody knew, what awaited the cosmonauts during the unprecedented experiment. Some even expressed the thought that the cosmonaut, after stepping out into the universe, might be "cooked" onto the ship. There were also other strange theories.

"We were prepared for the unexpected. During training we practiced the principle: hard on earth, easy in space.

"We cosmonauts had to be prepared for many things. Whereas Gagarin's flight was preceded by about a thousand test cycles, we had to go through about 5,000. I refer to a few entries from my diary, which characterize the extent of our physical training: I traveled more than 1,000 km on a bicycle from April 1964 through March 1965, I skied for several hundred kilometers during the winter of 1964 and 1965, and my weekly cross country training also amounted to many hundreds of kilometers.

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[1]"Man's First Space Walk," AVIATSIYA I KOSMONAVTIKA (Aviation and Cosmonautics), No 3, 1970, p 30.

"We devoted a great deal of attention to vestibular exercises, of which we did more than 150.

"We recognized the importance of the space walk experiment. It had to be done for the first time in human history. Everything had to be done very carefully, and we endeavored to perform the operations strictly by the book, exercising precision and diligence in all our actions."[1]

It should be pointedoout that the distinguishing feature of the training of cosmonauts for forthcoming space flights and for perfecting their professional skills is that it takes place only in training ships, whereas in aviation trainers and other airplanes are employed, in which each individual aviator is administered flight exercises in the air.

Thus, whereas the main type of training of aviators consists of training flights in airplanes, and simulator training is of secondary importance, simulator training is of deciding importance for the professional training of cosmonauts.

In this connection the requirements on the training of cosmonauts in simulators, on stands and other training equipment are exceedingly rigid. This equipment simulates space flight conditions and factors, emergency situations, simulates the operation of individual systems and flight dynamics, and also helps to develop the skills required to control the ship and its systems.

A. A. Leonov and P. I. Belyayev also underwent training for the purpose of developing the skills of maneuvering in outer space.

These exercises took place in an airborne laboratory, in which a short-term state of weightlessness was created. The cosmonauts performed training exercises in space suits and purposeful movements in accordance with the flight program. Inside this airborne laboratory was a full-scale mockup of the "Voskhod-2" spaceship and airlock.

Leonov's training process is described in the book by A. A. Leonov and V. I. Lebedev "Vospriyatiye Prostranstva i Vremeni v Kosmose" (Perception of Space and Time in the Cosmos) (Nauka, 1968):

..."The performance of the basic stage of the mission, the space walk and return to the spaceship, was conceived (and accordingly developed) as a series of successive operations. The cosmonaut, before entering the airlock, straps on his backpack with its self-contained life support system and hooks it up to his space suit. This is followed by a check of the equipment that aids the astronaut in leaving the ship, and equalization of the pressure in the airlock and cockpit. Then the cosmonaut enters the airlock, where he checks the tightness of the seal and space suit, the

[1]A. Leonov, "Steps in the Universe," AVIATSIYA I KOSMONAVTIKA, No 5, 1966, pp 27-29.

Figure 1. Cosmonauts take training exercises on centrifuges before a flight. Aleksey Leonov also underwent such training.

position of the light filters and oxygen supply. After that the flight commander closes the hatch in the cockpit, depressurizes the airlock and opens the outer hatch. The cosmonaut then climbs out of the spaceship and under conditions of referenceless space performs the planned number of exits from the airlock and approaches to it and finally returns to the cockpit. He must perform a total of about six operations when strapped in his work position, the flight couch, eight in the unstrapped state while moving about in the cockpit, and four while floating in space outside the spaceship. The mapping out of all these operations produced a perfectly clear picture.

"Being strapped in the work position proved to provide a sufficiently high quality of performance of the operations prescribed by the program. During the first two weightlessness training flights changes were observed in the coordination of movements (slipup). Such mistakes did not occur in subsequent flights. Movements in the unstrapped position while moving about inside the spaceship and airlock were more difficult to perform. Here the cosmonauts were deprived to some extent of a reliable point of reference. They simply bumped about the side of the spaceship and airlock. By the same token the character of routine operations was also more complicated. Many muscle groups of the body and extremities took part in their performance, with the result that coordination dislocations were more pronounced. The quality of performance of operations depended to a great extent on the force of the push against the wall of the spaceship or airlock. In the case of vigorous pushes the passage through the hatch was rather fast, but there was a danger of striking surrounding objects. In the case of gentle pushes the exercise often was not completed. The task was also greatly complicated by the presence of special gear, namely the space suit, particularly when the pressure necessary for a space walk was maintained in it.

"As regards approaches to the spaceship and especially departures from it, the required skills took considerable time to master. The criteria by which the completion of an exercise was judged were the smoothness of movement and time of the operation. By Leonov's account, 'the very first departure was the best one, unmatched. In one "hill" (i.e., steep climb of the airplane and dive -- I. B.) I got out of the airlock and re-entered it.' This success may be attributed to some extent to repeated and attentive viewing of movies, where the corresponding movements of the two test subjects were impressed, as though by repeated 'playing,' of all the required operations in the mind, and to personal experience accumulated in zero g flights. After the first success, nevertheless, Leonov had to practice quite a bit in order to learn how to reproduce it. Just learning the skills of completing a smooth exit from the airlock without turning around required six tries, and four tries were required for the approach to the airlock. At first the movements were sharp and were accompanied by rotation of the body on both the vertical and horizontal axes. During the first three flights the exits required 19-20 seconds, compared with 6-8 seconds during the last flights. No reduction of the time was observed during practicing of the approaches. To the contrary, it increased. Little time was left for this operation during the first approaches, the cosmonauts hurried, and this resulted in a reduction of the quality of completion of the assignment. The subjects approached the airlock not smoothly, but jerkily, turned on their side and even on their back. At the end of the training cycle, however, they were completing their exits and approaches properly and in the optimum amount of time."

Figure 2. Future flight commander of spaceship "Voskhod-2" Pavel Belyayev in preflight training.

Figure 3. Physicians carefully prepare A. A. Leonov for scheduled training.

After the training exercises A. A. Leonov wrote in his record of that period the following: "I got through the flight satisfactorily. I didn't

feel any unpleasant sensations. The sensation I felt was the same as I experienced on previous zero g flights. The space suit restricts my movements somewhat and the space helmet narrows my field of view. The approachesto the airlock were easy to perform, since I tugged on the tether, thereby creating a reference point, giving me a sense of direction. The entrances and exits should be done smoothly. Obviously any task can be performed in weightlessness without appreciable disruption of coordination in the presence of the slightest reference point."[1]

Not only problems of movement in referenceless space, but also problems of complete orientation under such unusual conditions had to be solved in connection with preparations for the space walk. Many people know that Soviet and American astronauts, before A. A. Leonov's space walk, flew and performed scientific-technical and biomedical experiments inside the spaceship, within the confines of a "ceiling" and "floor" and with an "up" and "down." Putting it briefly, they were flying in a referenceless state, but in all cases they were confined within the cabin of their spaceship.

A. A. Leonov had to contend with completely different flight conditions, i.e., be all alone in space and perform programmed experiments, which should be of great practical importance in future space exploration.

The choice of crew and the distribution of functions between its members were very important for the successful completion of the assignments of each individual space flight. This was especially necessary to ensure a high degree of cooperation between the crew members, a phenomenon called "psychological compatibility" in scientific language. Much attention is devoted in aviation to this problem during the formation and selection of crews, especially for multiplace airplanes, consisting of pilots, engineers, technicians, navigators, radio operators and other specialists. Indeed, the crew of such an airplane must perform important flight missions under complicated meteorological and tactical conditions. In such a situation the mission can be accomplished smoothly, precisely, on time and completely only when all the crew members have a high degree of special and physical training and personality and psychological qualities.

This is why so much attention was devoted to these problems during the selection of the crew of "Voskhod-2." And this is understandable, since strict harmony, cooperation, mutual understanding and trust were required of this crew in order to complete the world's first space walk experiment in outer space. P. I. Belyayev, in terms of character, is a man of great determination, tenacity, composure, a logical thinker with profound self-analysis, great persistence, etc. A. A. Leonov, in terms of temperament, is restless, impulsive and is capable of performing tirelessly in any situation, at the same time exhibiting courage, decisiveness and determination. They both made an excellent crew for the spaceship "Voskhod-2," completely prepared to solve a new and important problem in space exploration.

[1]A. A. Leonov and V. I. Lebedev, "Vospriyatiye Prostranstva i Vremeni v Kosmose," Moscow, Nauka, 1968, pp 63-64.

Figure 4. Aleksey Leonov after flight training in jet airplane.

P. I. Belyayev and A. A. Leonov worked together harmoniously, with a profound understanding of the tasks of the forthcoming flight, even during the simulator training process.

That A. A. Leonov and P. I. Belyayev, who were fighter pilots before they joined the ranks of the cosmonauts, already had the prerequisite professional skills, such as reaction speed, concentration, attention, decisiveness, courage, etc., was very important. This helped to speed up the development of various exercises during preparatory training for flight aboard the spaceship "Voskhod-2."

Here is what G. S. Titov said in response to the question of what form of training is most important for the preparation of man for space flight: "Flights in modern supersonic airplanes. They develop not only strength and reaction, like sports and calisthenics, but also professional qualities. Each flight is a complex training assignment." It is known that G. S. Titov flew a great deal in modern aircraft. He confirmed military pilot first class in 1967 and became a test pilot.

Parachute jumps also occupy a certain place in the training of cosmonauts. This applies primarily to psychological and special problems of cosmonaut training. Parachute jumps instill will power, decisiveness, determination, fast reaction, courage, etc.

During preparation for the forthcoming space flight A. A. Leonov did 117 jumps and acquired the title "Parachutist-Instructor." Parachute jumps of varying complexity from airplanes had some influence on A. A. Leonov in overcoming the "psychological barrier" in regard to referenceless space.

A. A. Leonov says the following about this:

"I also had to strengthen my vestibular system.

"We were certain from the very beginning that we would do everything right. There was a different concern at first -- overcoming the psychological barrier and the possibility of being cold-cooked in space.

"Konstantin Eduardovich Tsiolkovskiy wrote about the psychological barrier that a man might experience when leaving the spaceship for the first time to step into the abyss. This is the barrier that the parachutist overcomes when he takes his first jump from an airplane.

"We reasoned it out approximately as follows. We have flown in airplanes and have made parachute jumps. Therefore the psychological barrier could not have been a serious obstacle to us. We are normal, healthy people, and healthy man should react to everything as a healthy man."[1]

"To walk into space," said A. A. Leonov, "was a task to be done in a special space suit, under an excess pressure of 0.4 atmosphere, with a self-contained life support system. It was not easy to work in such a space suit. For example, it took a force of 25 kg just to squeeze a hand in the glove. Therefore I and my backup Yevgeniy Vasil'yevich Khrunov paid a great deal of attention to physical training and sports. We trained a great deal, according to all the rules of science.

"We had to develop dynamic endurance and to learn how to work for a long time under stress. Every day in the summer, in addition to exercises in the gymnasium, we ran 7-8 km and skied 10 km every day in the winter."[2]

As an athletic commissar I would like to talk at greater length here about the physical training of the cosmonauts.

Modern aerospace technology, as we have already mentioned, is equipped with extremely sophisticated electronic, navigation and other systems, which not only must be thoroughly learned, but also intelligently and appropriately used under the complex conditions of space flight. In order to meet these requirements it is necessary to resort to a long-term, diversified planned training program to prepare people for space flight. What I am talking about here is technical, psychophysiological and physical training. Since the first days of the establishment of the Cosmonaut Training Center, when people began to be trained for space flight, priority has been given to physical training. This is understandable, since only a healthy, physically well-conditioned man with a high level of mental development and considerable technical skills, can become a space crew member. The experience compiled by cosmonauts during space flights shows that not enough studies have yet been done in relation to the influence of all factors on the human body. Take the state of weightlessness, for example. This unusual and as yet not completely

[1]"Man's First Space Walk," AVIATSIYA I KOSMONAVTIKA, No 3, 1970, p 30.
[2]"Man's First Space Walk," AVIATSIYA I KOSMONAVTIKA, No 3, 1970, p 30.

analyzed phenomenon may lead to undesirable consequences for a cosmonaut, flying an extended flight in a spaceship, if he is not thoroughly prepared for it. Weightlessness has a considerable effect on the general health and performance of the cosmonaut, causes damage in certain sensory organs, influences the vestibular apparatus, organs of the digestive system and circulatory system and produces dizziness and general fatigue.

Man's exposure to weightlessness during relatively long space flights (14 days in "Gemini-7," 18 days in "Soyuz-9," 24 days in "Soyuz-11"-"Salyut" and 84 days in "Skylab") has shown that cosmonauts, in addition to experiencing unpleasant sensations, lost weight as a result of shrinkage of muscle mass and some dehydration, since their bodies lose calcium salts faster than under ordinary conditions.

Scientists are interested in all phenomena that cosmonauts experience in the state of weightlessness during extended flights and are undoubtedly conducting extensive studies on the stated problems. Long-term general physical and vestibular training and exercises by a special program are means of preventing the unpleasant sensations associated with this state.

In addition each cosmonaut usually must properly plan his own routine of work and rest. Recreation, which includes not only physical exercises, games, etc., but also knowing when to change from one type of activity to another, is very important for the restoration of a cosmonaut's ability to do work. These requirements are imposed on the cosmonauts not only during the period of their space flight training, but also during the flight process itself, no matter how long and complex it might be.

All of these problems are the concern of space medicine.

Each space flight has its own task, time periods and features, on which depend the general and physical training programs. Cosmonauts must be of sound health, able to withstand the effect of g-forces, barometric pressure drops, deficient oxygen, their vestibular system must not be too sensitive, they must be able to endure great physical stress and remain calm, balanced, composed and organized.

The selection of future cosmonauts is done in accordance with extremely rigid criteria in consideration of general health, physical development (height and weight), physiological features, resistance to temperature drops and deficient oxygen, psychic qualities (psychic stress, sense of seclusion, fear, etc.) and physical training.

These qualities of future cosmonauts are checked in altitude chambers, on centrifuges and vibration stands, in surdochambers and other trainers.

The physical training program for cosmonauts is set up as follows: preliminary space flight training, preflight training, in-flight training (special exercises) and post-flight training (to restore muscle strength, coordination and vestibular functions).

All Soviet aviator-cosmonauts, when undergoing special training exercises in preparation for forthcoming flights, spend a great deal of time in ordinary types of athletics (swimming, skiing, hockey, volley ball, soccer, running, jumping, horizontal bars, parallel bars, etc.). Physical training is conducted in consideration of the individual features of each person.

Studies have shown that athletic activities are very beneficial in terms of the general preparation of a cosmonaut for flight. For example the speed of visual perception is increased by 1.5-2 times, motor reaction speed is increased by 25-30%, the rate of visual adaptation is increased, vestibular functions are improved and faster automation of response reactions during work with various devices is developed.

Thus cosmonauts are morally, mentally, physically, psychologically and technically prepared for space flight and for the completion of the space exploration program.

Our cosmonauts, who are paving the road into space, talk about this subject below.

The flight conditions, according to Yu. A. Gagarin, turned out to be even somewhat less rigorous than those under which he trained. He did not sense overloads in space and he retained a keen awareness at all times. He endured the state of weightlessness quite satisfactorily and his performance and coordination remained good throughout the entire flight.

Ya. A. Egolinskiy describes the flight conditions and physical training of the cosmonauts: "Yu. Gagarin said of his space flight: '... I heard a whistling sound and a steadily mounting roar, I felt the gigantic spaceship begin to shudder with its whole body and slowly, very slowly lift off from the launch pad. The roar was no louder than what you hear in the cockpit of a jet airplane. The g-forces began to build up. I felt as though some unknown force was pressing me into the couch..., I had difficulty lifting my arms and legs. I knew that this condition would not last long, just until the spaceship achieved orbital insertion velocity. The g-forces continued to increase..., but I gradually became accustomed to them, and the thought even occurred to me that I had to endure more on the centrifuge. The vibrations were also substantially stronger during training. In a word, it was not so strange as it was reputed to be.'

"G. Titov describes the final and especially difficult stage of the flight as follows: '... "Vostok-2" entered the dense layers of the atmosphere. Its heat shield heated up rapidly, producing a bright glow in the air streaming past the ship... Weightlessness disappeared completely. The increasing g-forces pressed me into my couch with an enormous force. It felt as though some weight was crushing my body. "Let's get this over with in a hurry," I thought to myself. And the force that was bearing down upon me actually began to weaken gradually. Everything became easier and easier.'

"Yu. Gagarin's physical training consisted of daily morning exercises for 30-40 minutes. They were intended to involve all muscle groups, and in Yu. Gagarin's opinion they were an important part of his physical training program. He also engaged weekly in several special training exercises in certain types of athletics. The basic purpose of all the training exercises was 'to increase my reserve of physical strength.'

"G. Titov started his physical training program while he was still in school. He loved to play basketball and he rode the bicycle, sometimes as far as 100 km in hot weather. In 1953 young Titov took first place in rayon bicycling races and he was an outstanding soccer player from the 6th through 10th grades. In the 7th grade G. Titov began gymnastics, in which he later reached second class. As a military aviator he trained in acrobatics and participated in group acrobatic exercises as a 'stoyechnik,' performing elements of classes 2 and 1. G. Titov, with his gymnastic and acrobatic training behind him, quickly mastered skydiving, completed several dozen jumps and was awarded the title of parachutist-instructor.

"During space flight preparation G. Titov engaged in an extensive training program. In the mornings he did a long session of calisthenics, starting with running, followed by gymnastics and other exercises. Special exercises included batud training and dives into the water from the high board and from a trampoline. To develop his endurance he continued bicycling and athletic games, and to accustom himself to weightlessness he made flights in a special airplane. The first sensations of weightlessness were even pleasant to the pilot...

"A. Nikolayev began his physical training while still in grade school. He played volley ball, ran, swam, spent a lot of time skiing, gradually building up his endurance, and at age 15-16 he took part in skiing contests. Entering forestry at age 18, A. Nikolayev often engaged in physical labor, continued to build up his strength and endurance. In the army the future cosmonaut regularly took part in light athletics, skiing and gymnastics.

"A. Nikolayev devoted much attention during space flight training to physical training and exercises with special equipment to increase vestibular stability and the resistance of his body to g-forces (diving and gymnastics). A. Nikolayev worked out for hours on end on a special swing, grasping metal rods with his eyes closed. He gained the ability to easily become oriented in space and to maintain his equilibrium and coordination under various difficult conditions.

"During their flight A. Nikolayev and P. Popovich did physical exercises to improve circulation, to increase cerebral stimulability and to maintain muscle tone. These exercises were stepped up before landing in order to prepare the body for the forthcoming g-forces.

"P. Popovich also began physical training during his school years. He skied, rode horseback and ran. Later he became interested in weightlifting, boxing, ski jumping and soccer. In the military service he became involved in gymnastics and stepped up his skiing and weightlifting training.

"During space flight preparation P. Popovich worked out a great deal with special apparatus and like A. Nikolayev placed emphasis on increasing his vestibular stability. To accomplish this he did exercises on swings, on the merry-go-round, seesaw and gymnastic wheel, and to increase his resistance to accelerations he did exercises aimed at developing g-force endurance.

"While performing exercises during flight under conditions of weightlessness P. Popovich noticed that he felt a return of strength and spirit. All the cosmonauts consider a diversified physical training program to be essential for space flight.

"'What is required of a cosmonaut,' said Yu. Gagarin. 'In addition to determination and tenacity are great endurance and strength, "a reserve of physical strength,"... These qualities are developed by training. "Record-setting" efforts are not required here, but rather various athletic activities... And here is another piece of advice: pay attention to the work-rest-diet regimen. Don't be preoccupied with trivia'...

"To teach men how to make efficient utilization of physical training methods for self-training and temperament and character improvement is a very important aspect of the physical training program of the cosmonauts."[1]

On the eve of the flight of the spaceship "Voskhod-2," when the International Astronautics Commission of FAI [International Aviation Federation] had not yet developed and confirmed the new rules for registering record-setting scientific and technical achievements for multiplace spaceships, we were forced to request that this organization make changes in the then existing rules of the Sports Code. What were these changes?

I well remember the controversies at FAI that raged on the eve of the flight of the world's first multiplace spaceship "Voskhod" with a crew consisting of three aviator-cosmonauts: commander Vladimir Komarov, scientist Konstantin Feoktistov and physician Boris Yegorov.

At that time the United States representatives stubbornly insisted that FAI adopt the position, in accordance with which world records would be listed not in terms of the size of the crew, but in terms of the weight of the spaceship. They claimed that that would stimulate progress in space technology and would increase the role of only one astronaut, and not of all crew members, in the control of spaceships, asserting that the other crew members have nothing to do with control and flight.

Thus the Americans contended that anybody in a spaceship other than the commander should not be considered a crew member, but simply a passenger. The aruments of the representatives of the United States, of course, were

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[1]Ya. A. Egolinskiy, "Polety v Kosmos i Fizicheskaya Kul'tura Molodezhi" (Space Flights and Physical Training for Young People), Leningrad, Izd. obshchestva Znaniye, 1967, pp 24-27.

unconvincing and had nothing in common with the great tasks that had to be done for the future investigation and exploration of space by man.

It seems to me that the biggest mistake of the Americans was the fact that they did not attach enough importance to such a major factor as the role of man, or more accurately of a staff (I speak here of the crew of the spaceship) in space exploration. The importance of the staff (crew) was eventually borne out by the flights of such multiplace spaceships as "Voskhod," "Soyuz" and "Apollo."

Today space biology and medicine have at their disposal enough scientific data to permit the preparation and completion of extended manned space flights. Science attaches much significance to the psychological state of the cosmonaut in the solution of problems of manned space flights to the Moon, Mars, Venus and other planets. Take, for example, the world's first multiple space flight of the Soviet aviator-cosmonauts Andriyan Nikolayev and Pavel Popovich in the spaceships "Vostok-3" and "Vostok-4." Nikolayev went up first, soon to be joined by Popovich. The two of them had a gay and interesting time up there together.

Now imagine an emergency that might occur in space. Under such conditions an cosmonaut, all by himself in the spaceship, may decide, after losing all communications with the earth, to rely on his own judgment. This is one of the reasons why we attach so much importance to flying spaceships with a crew consisting of several members.

Much has changed during the development of astronautics. Flight problems have become more sophisticated. The role of man as a direct participant in space flight and as a crew member of a spaceship, is increasing. New spaceships will be built in the future for exploring both near (near-earth) space and far, interplanetary space (the cosmos).

With the development of aviation technology and the appearance of airplanes, intended for various purposes, the makeup of the crew naturally also has changed. At first an airplane was flown by one man, the pilot. Then, after the introduction of multipurpose airplanes, the crew appeared, consisting at first of one more member, an aviator observer (this occurred first in Russia in 1911), followed by the three-man crew, etc. Today the crew of modern jet airplanes consists of several members, who along with the commander and copilot perform complex and diversified operations associated with flight control and support.

A long flight, lasting many hours, requires of the crew of the airplane cohesiveness, smoothly organized collective work, thorough knowledge of functional responsibilities, endurance, composure and instantaneous reaction. But the flight of a modern airplane differs vastly from the flight of a spaceship, since it takes place in completely different conditions and for different purposes. In connection with the problem of future systematic space exploration the crews of spaceships will include not only an aviator-cosmonaut, but also scientists, physicians, geologists and other specialists.

Therefore we introduced a proposal at FAI concerning a new classification of space records in accordance with the given category. We first suggested the development of a new basis for the classification of spaceships in accordance with flight mission. We had in mind research projects that might be conducted by the crew of a spaceship, and also tasks assigned to the crew. The fact is that the volume of research which a crew carries out depends to a great extent on the design of the ship and on the number of crew members. Up until then the size of the payload, placed in orbit by the booster rocket, was the main criterion. Such a criterion is arbitrary and not objective enough.

It is more correct, in our opinion, to classify spaceships in accordance with the size of the crew. It is obvious to us that by increasing the size of theccrew during the exploration of space it will be possible to undertake a more extensive scientific research program, basedoon the extensive application of the division of labor principle. This is especially important for extended space journeys, since the spaceships will be controlled not only automatically or by radio command from the earth, but also by the crews. In this case the commander, the pilot of the spaceship, and other crew members will perform important functions.

When solving problems related to manned spacefflight, not only in earth orbit, but also to the planets of our solar system, we must always consider the important psychological factor of collectivism. I could cite innumerable examples of the cohesiveness of the Soviet collective, its friendship, mutual understanding, devotion to duty, profound mutual respect of the people during the solution of the most difficult problems. Some examples are the mass combat and constructive heroism of October 1917, of the civil war, the first Five-Year Plans, the Great Patriotic War and post-war recovery of the devastated economy of our country.

We have compiled considerable space flight experience, but space flight remains complex and hazardous. The problem of the relationship between man and spaceship is especially difficult.

No automaton or instrument can completely replace man in the performance of various operations, either on earth or in space. The duration of space travel depends on the psychological endurance of all members of the crew, on living conditions in the spaceship, on the reliability of all systems of the ship, especially the life support systems and the possible amount of supplies consumed by each crew member. The supplies aboard a spaceship, necessary for maintaining viability, will depend on the number of crew members.

Thus it may be concluded that the launch weight, and accordingly the duration of flight will depend to a great extent on the number of crew members of the spaceship.

Analysis of the energy consumption of an astronaut (crew member) and determination of the daily per man requirement of various supplies and

materials using recycling (closed ecosystems) will make it possible to reduce launch weight. And the use and continued perfection of life support systems by means of the recycling of water, oxygen and the partial and complete recycling of food will substantially reduce the dependence of launch mass on the projected flight duration.

It may be concluded, furthermore, that the use of closed ecosystems will practically eliminate the dependence of launch weight on flight duration. Therefore the confirmation of flight time records as functions of the number of crew members of the spaceships will promote the perfection of life support systems.

Thus the classification of spaceships as single-place and multiplace (from two to four and more men) when determining record achievements is justified from the standpoint of the possibility of achieving maximum flight time.

The establishment of record flight distances and durations for multiplace spaceships will encourage spaceship designers to provide the best possible health conditions in the cabins and will also promote the development by astronauts of the qualities required for completing long-range space voyages.

The suggestions of the Soviet Union concerning the registration of records set by multiplace spaceships in terms of the number of crew members, submitted for consideration to the International Astronautics Commission of FAI, were eventually approved. Thus the Soviet view as to the increasing importance of a group of cosmonauts in space flights received official international recognition.

The International Astronautics Commission of FAI examined very carefully the Soviet suggestion concerning a new class of records for the time spent by cosmonauts outside the spaceship in a space suit with an individual life support system, i.e., when a cosmonaut leaves his spaceship and moves about freely in space.

Our suggestion concerning the registration of a category of records for the minimum time spent on the docking (rendezvous) of manned spaceships in space also attracted attention.

These new suggestions concerning space records were incorporated in the Sports Code of FAI.

The first two classes of records mentioned above, first of all, should apply not only to the earth orbital class of flights, but also to flights to other planets of our solar system. Secondly, for the category of docking (rendezvous) records it is necessary to register as records not only the minimum time spent on docking, but also on the maximum weight of the docked ships and the maximum space flight altitude.

As for the category of space walk records, the Soviet amendment on the confirmation of records not only on the maximum time spent by an astronaut in outer space, outside the confines of his spaceship, but also on all classes of records that are presently registered in accordance with the affirmed and active rules of the Sports Code of FAI, except for the flight duration record, was adopted. This amendment pertains to record maximum altitude, maximum weight and distance.

Somewhat later world records on the time spent by an astronaut (astronauts) outside the spaceship were made to include space flights to other planets and landing upon them. The time spent by an astronaut (astronauts) on the surface of the planet inside the spaceship, outside the spaceship, and also the distance which they cover by unaided walking and individually by means of a self-propelled vehicle (Lunokhod, for example), are also taken into consideration in this case.

All the proposals on the new category of records, submitted to FAI, were adopted.

BEFORE LAUNCH

The airplane that was to take us to Baykonur cosmodrome was scheduled to take off at 0800 hours of 9 March 1965. The thermometer in Moscow read -16°, but we were told that the weather at the cosmodrome was sunny and warm and the temperature there was +16°. An An-10 airplane was already completely ready for takeoff at a suburban Moscow airfield, from which we were to depart. A few minutes after our arrival a "Volga" pulled up, from which stepped the world's first cosmonaut Yu. A. Gagarin, the first space flight commander V. M. Komarov and two well-built officers, attired in full dress uniform. Their names were Pavel Ivanovich Belyayev and Aleksey Arkhipovich Leonov, the new space crew, whose mission would be to perform an exceedingly complex and unprecedented experiment in space.

I knew P. I. Belyayev and A. A. Leonov well from previous space flights, having met them in Moscow. At the cosmodrome A. A. Leonov and I accompanied V. V. Tereshkova, the world's first female cosmonaut, to the launching pad and met her at the landing site.

We became engaged in a lively conversation following warm handshakes. Permit me to talk about it briefly. At the airport were the trainers and supervisors of the cosmonauts, among whom were Hero of the Soviet Union N. P. Kamanin, who is deeply respected by all cosmonauts. To accompany to the cosmodrome and on the long, difficult and important space voyage of P. I. Belyayev and A. A. Leonov came V. V. Nikolayeva-Tereshkova, A. G. Nikolayev and V. F. Bykovskiy. Valentina Vladimirovna handed Aleksey Arkhipovich Leonov a bouquet of tulips. On a greeting card she wrote: "Goodbye friends. Good luck toyyou on your flight and space journey. Looking forward to meeting you soon in Moscow!"

All are invited into the airplane. We take our places in its spacious cabin. Next to me sits Aleksey Arkhipovich Leonov and behind us are Pavel Ivanovich Belyayev and Vladimir Mikhaylovich Komarov. One of them, V. M. Komarov, had already traveled in space as flight commander of "Voskhod," and P. I. Belyayev was designated also as a flight commander, but with a different, more sophisticated mission. Nevertheless the experience that was gained during V. M. Komarov's flight in the three-place spaceship, in

which a scientist and physician flew for the first time, had to be conveyed to his friend and colleague. I heard their conversation well. V. M. Komarov talks unhurriedly and in detail about the control of the spaceship, about the operation of all its systems and especially about the use of the automatic routine for re-entry and landing, in which soft landing was used for the first time in space flight practice. They were together almost the entire trip from Moscow to Baykonur.

Yuriy Alekseyevich Gagarin sat in a different cabin, near the cockpit. He is a courageous, modest and charming man whom we all love deeply and respect profoundly. Pavel Ivanovich Belyayev, during our meeting in "Zvezdnyy gorodok," long before the forthcoming flight, talked in glowing terms about this remarkable comrade: "To be with Yuriy is a source of tremendous satisfaction. He is intelligent, pleasant and at the same time dedicated to his work and to his colleagues. He has always set an example for us in all respects."

On 12 April 1961 all systems of the "Vostok" spaceship were subjected to what is known as a "space examination." Also examined was the man, whom this ship would take forthe first time to the unprecedented altitude of 327 km. During one orbit around the earth he was subjected to a "volley" of tremendous accelerations, conversion to weightlessness, immediately followed by sudden deceleration, which is even more difficult than the acceleration of launch. Yuriy Gagarin was the first to step up to the new level of velocities, achieved by space technology. This brave man of the earth, our compatriot, by his unparalleled exploit, extended the path into the universe and proved that man can travel successfully beyond our planet and conduct space flights there. The cosmic track, traced by Soviet fellow Yuriy Gagarin in the celestial wasteland will remain forever in the memory of all mankind.

Now he will fly to Baykonur cosmodrome not only to witness the flight of yet another Soviet spaceship into space, but also to relay his experience and to supervise the prelaunch training of the crew and of the entire launch complex for the completion of a new and important scientific-technical experiment.

The airplane taxiis slowly onto the runway. It takes off precisely at the designated time and takes a heading toward the cosmodrome.

A short time later the An-10 reaches an altitude of 8,000 meters. The flight speed is 650 km/hr. Outside at this altitude the temperature is -60°. The sky is cloudless and clear. Down below the earth is covered with a heavy layer of snow. I hasten to add that of all the times that I had an opportunity to fly the unusual trip to Baykonur cosmodrome, this was the first time that I saw the earth covered with a heavy layer of snow. This was somehow unusual to me and to all the passengers on that plane. The fact is that all the flights of our cosmonauts took place basically when the weather was warm and our earth received her space travelers covered with green vegetation.

Aleksey Arkhipovich Leonov and I, as we conversed, recalled all the events that occurred during the days of our visit to the cosmodrome. We laughed when I reminded him of the caricature he drew of representatives of the press in the wall newspaper during the prelaunch days preceding the flights of "Vostok-5" and "Vostok-6." Then Aleksey Arkhipovich showed me a photograph of his daughter Viktoriya, who was 4 years old in April. I sensed that he loves her very dearly.

Pavel Ivanovich Belyayev continued his conversation with V. M. Komarov, commander of the world's first multiplace spaceship. P. I. Belyayev listened very attentively, memorizing everyword and sentence. Thus the two of them continued almost until the very landing of our airplane at the airfield of the cosmodrome.

A. A. Leonov, "Fidgets" as I called him, could not sit in one place very long. Highly spirited, happy and very mobile and friendly, he was always talking with one or another passenger. This determined and decisive man, so far as I know, never became dejected. He always could make friends, find a common language with them and win the favor of his associates. P. I. Belyayev is a man of a different fold. He is introspective, aloof and not very talkative. His answers to questions are short and to the point. The attitude of all to this man of great spirit is one of deep respect.

The flight continues and our air journey will be over soon. The commander of the airplane enters our cabin and announces: "We will be landing in 1 hour. We will begin our descent soon." This announcement did not surprise anybody. Everyone calmly went about his business. Only Yuriy Alekseyevich Gagarin, sitting near us, said: "Why sleep? It is time to get up. We can sleep at the cosmodrome."

Yu. A. Gagarin, walking up to P. I. Belyayev and putting an arm around him, said: "Well, Pavel, it just occurred to me! Soon we shall be landing and be getting ready for work." In response to these words P. I. Belyayev remarked: "I am always ready."

The airplane began to descend.

I peer out the window and see that there is no snow on the ground. Below is a silent desert. The sun is shining above as though it were summer. Dry lake beds can be seen here and there.

The airplane begins to descend rapidly. The needle of the altimeter approaches the number 2; this means that we are at an altitude of 2,000 m.

In the airplane all begin to get things together. The altimeter shows 100 m. We see the familiar air strip, where we have landed many times before and from which, after the successful launches and landings of our heroes, have taken off on a heading toward Moscow, the capital of our country.

Soon after landing and taxiing to the tarmac a large group of people come to meet the airplane. Among them I see the chairman of the State Commission, Academician S. P. Korolev, his deputies and other members of the commission, who have already arrived at the cosmodrome. Cosmodrome officials, service chiefs and aviators come to greet all of us who have just flown in from Moscow.

The first to disembark are Yu. A. Gagarin, V. M. Komarov, followed by P. I. Belyayev, A. A. Leonov and their backups. The cosmonauts are very warmly and heartily greeted by all members of the welcoming committee. Toward us walked the chairman of the State Commission and S. P. Korolev, who fatherly welcomed the cosmonauts and all others who arrived on this trip from Moscow.

Business conversations immediately begin to take place near the airplane. S. P. Korolev is interested in how the cosmonauts feel and in their frame of mind.

After this brief, but moving reception we all board a bus and go to a hotel, where in October 1964 I spent my leisure time during the prelaunch days prior to the flight of the crew of the "Voskhod" spaceship.

On that very same day, immediately after dinner, P. I. Belyayev, A. A. Leonov, Yu. A. Gagarin, V. M. Komarov and N. P. Kamanin departed with a group of technical personnel to the launch site for training. On the next day the future crew also stayed at the launch site from dawn to dusk, preparing for the new space journey. It was there that I met Boris Borisovich Yegorov, who arrived at the cosmodrome several days ahead of us. As a physician with practical experience associated with space flight, he, of course, was able to give useful and necessary advice to the new space crew.

At the assembly-testing building I met Sergey Pavlovich Korolev, who asked me to meet with him on the next day. As a matter of fact S. P. Korolev asked me back in Moscow to explain some problems related to the recording and format of new categories of space records which might be sent by the crew of "Voskhod-2."

On the next day, 11 March, we did meet, not at his office, as I previously assumed, but at the assembly-testing complex (MIK), near the spaceship "Voskhod-2," where P. I. Belyayev and A. A. Leonov were undergoing training at that time in the cabin. I showed S. P. Korolev the FAI Sports code and explained to him the new categories of space records that were designated for re-examination at the next scheduled meeting of the International Astronautics Commission of FAI. After listening attentively to me he asked several questions about the registration of new records in connection with the "Voskhod-2" mission. At the end of our conversation he said: "I understand everything, but the main thing for us is to complete the designated flight program, land the ship and crew, and then add up the results."

After this meeting I remained at the ship and with the cosmonauts, scientists and engineers continued to observe P. I. Belyayev and A. A. Leonov in training. Also there were aviator-cosmonauts Yu. A. Gagarin and V. M. Komarov, who gave their friends necessary advice during the training process.

The cosmonauts also received practical prelaunch training earlier, directly inside the cabin of the spaceship. This was necessary so that each cosmonaut could personally inhabit, so to speak, his work position, check out all operations and review the layout of all switches, buttons and instruments in the cockpit.

P. I. Belyayev and A. A. Leonov very attentively and diligently rehearsed everything they were supposed to do in space during flight in this remarkable spacecraft.

That which A. A. Leonov had to do had never done before by any cosmonaut who had traveled in space. A. A. Leonov was supposed to leave the cabin of the spaceship and stay (float) for some time in outer space while the spaceship continued to fly at a great velocity (about 8 km/s, or 28,000 km/hr). This experiment, involving a space walk by a cosmonaut outside of the spaceship during free space flight, was of great scientific importance. What courage this man must possess, what will power he must have to perform this honorable, important and, if I may say so, risky assignment.

That is why S. P. Korolev and his aides were now devoting so much attention to these practical exercises and to the actions of the cosmonauts inside the spaceship. Cosmonaut A. A. Leonov, according to the program, would make his exit from the spaceship and remain near it for some time, while P. I. Belyayev would carefully watch the actions of his comrade, the operation of systems and equipment and render practical assistance as needed, if the unfolding situation so required.

This, as we found out, was an extremely complicated and very important mission. The major role in this experiment, of course, was set aside for the cosmonauts. Nevertheless a great deal of attention had to be devoted also to all instruments and systems that were to aid the cosmonauts in the completion of this assignment, both on board the spaceship and on earth.

When one examines the spaceship, standing in complete readiness for mating with the booster rocket, one is convinced once again of the greatness of the technological achievements of Soviet space technology, which is called upon to render faithful service to man in the conduct of space exploration.

After the scheduled training, at the hotel after our return from the launch facilities, I asked Aleksey Arkhipovich Leonov about his attitude toward these training exercises. Here is what he said to me: "From the very beginning, even before we came to the cosmodrome, when we were

starting practical training, I somehow felt uncomfortable in the space suit. It restricted my movements and actions. But I kept telling myself to ignore that and to faithfully and steadfastly continue training according to the preassigned program. The program, of course, was a difficult one. But today, when I took the scheduled training exercises with Pavel Ivanovich Belyayev, I no longer noticed this discomfort. That is what training is all about. It is easier, of course, without the space suit, as it was for the crew of "Voskhod." But they had one flight program, and we have a different one, and we must fly in space suits. P. I. Belyayev and I have different flight assignments, and they cannot be done without a space suit." Pavel Ivanovich Belyayev answered the same question as follows: "Training is necessary and mandatory for a cosmonaut. Without rehearsing and carefully polishing certain skills it is impossible to talk about the precise completion by a cosmonaut of the entire flight program. This is why Aleksey Arkhipovich and I devote so much attention to these exercises."

The cosmonauts prepare themselves for flight not just by sitting in the cockpit of the spaceship. P. I. Belyayev and A. A. Leonov, in addition to these exercises, had to analyze the itinerary of their flight every evening, maintaining a flight log, and to undergo training on the practical conduct of radio communications.

Our visit at the cosmodrome was marked by yet another important event. On 14 March it was my fortune, along with all the inhabitants of this historic place, to nominate candidates to the local Soviets. At 1000 hours we traveled by bus to the polling station along with the celebrated cosmonauts Yu. A. Gagarin and V. M. Komarov and those who would be launched into space in a few days aboard the spaceship "Voskhod-2." The electors of the cosmodrome greeted the appearance of Yu. A. Gagarin and V. M. Komarov with thundering applause. Movie cameras clattered and camera shutters clicked. P. I. Belyayev and A. A. Leonov voted along with Yu. A. Gagarin and V. M. Komarov.

The final prelaunch days were saturated with increasingly complicated and laborious training exercises, which were conducted under strict medical observation and control. The situation now was different. The cosmonauts had just a few days left before launch, and the physicians, responsible for their health, naturally intensified their control and observation. A cosmonaut launched into space must be completely healthy and physically strong. Only under these conditions can it be guaranteed that the flight program and the entire mission will be completed on time with precision and complete success.

P. I. Belyayev and A. A. Leonov spent all their free time on physical training. They lifted weights, ran a lot, did special physical exercises, played volley ball and table tennis, all under the physician's observation. The physicians of cosmonauts Andrey Viktorovich and Ivan Mikhaylovich knew their job well. They had great professional experience. That they enjoyed great authority among their cosmonaut patients was no accident.

The days passed swiftly. Soon prelaunch training was over, and then, as always, came the interview with the State Commission. After that P. I. Belyayev and A. A. Leonov left us for the cottage where all cosmonauts, in keeping with a tradition that is now firmly rooted here, undergo a thorough prelaunch medical examination. And then into space aboard "Voskhod-2," that distinguished and important space journey.

We knew about the makeup of the "Voskhod-2" crew at the cosmodrome, even before the flight. P. I. Belyayev was made the flight commander, and A. A. Leonov was assigned the task of leaving the spaceship into open space. That is the way they performed all essential training exercises, prescribed by the flight program. The State Commission had only to approve the "Voskhod-2" crew as assigned and the program of completion of the new scientific-technical experiment.

The design office made couches with back cushions and new space suits, substantially different from the previous ones, for each individual cosmonaut. Whereas the earlier space suits were bright orange in color, the new ones were completely white. The designers of the new space suits told me that the space suits in which P. I. Belyayev and A. A. Leonov would fly and walk in space had their own distinctive features. First of all they were made of new fabrics and had an individual self-contained life support system to enable man to work in space outside of the spaceship. Secondly, the new space suits were white so that they would reflect more sunlight and experience less overheating.

The weather changed suddenly at the cosmodrome. A north wind blew, snow fell and the temperature dropped below zero. It got cold. But such weather could not stand in the way of the cosmonauts and of those who were preparing the rocket and spaceship.

Today I met correspondents N. N. Denisov of PRAVDA, V. M. Peskov of KOMSOMOL'SKAYA PRAVDA, A. P. Romanov of TASS, G. N. Ostroumov of IZVESTIYA, V. V. Mikhaylov of APN ["Novosti" Press Agency], N. A. Mel'nikov of KRASNAYA ZVEZDA and Yu. A. Letunov of the All-Union Radio Network, who just flew into the cosmodrome. They have an important assignment: publicize in the press the events that will take place here, at the cosmodrome and in space.

Losing no time, they immediately went to work, interested in everything that had already taken place at the cosmodrome and in what was about to take place. They soon interviewed S. P. Korolev, the chairman of the State Commission, leading designers, cosmodrome officials and cosmonauts.

S. P. Korolev's interview with the correspondents lasted for 75 minutes. I had the honor of attending that interview. I will attempt to relay this interview, recorded on magnetic tape by radio operator Yu. Letunov:

"Three-story building. Long corridor. From room, on the door of which is a sign that says 'Technical Supervisor,' comes man of average stature, in dark gray suit and blue shirt.

"He stops to talk with someone. He asks, listens attentively. Gives advice. Looks at his watch. Journalists await him in office, in which State Commission usually meets. Note pads are opened, microphone is turned on."

"Well comrades I am ready to answer your questions. How would you like to conduct this interview -- would you like to ask questions, or should I give you an account of something?"

Thus the chief designer of spaceships began his press conference on the eve of the launch of "Voskhod-2." As during previous visits at the cosmodrome, I made a few documentary recordings.

But this interview with S. P. Korolev is especially dear to me. The scientist talked about many things, as though he were thinking aloud:

"Well, what may I tell you about this flight? The flight is unusual, even in terms of our space flight experience. The distinguishing feature of this space flight is the fact that one of the cosmonauts, while in orbit, should pass through the airlock into space and spend a short time out there. While in space the aviator-cosmonaut should perform several operations associated with movements, with maneuvering in space, necessary for taking movies. He himself will shoot the film, and he, in turn, will be photographed from inside the spaceship. He should then remove the camera from the bracket, place his camera in a pocket, re-enter the hatch, perform all hatch operations there and return to the ship, after which the flight will continue in the usual, familiar orbit. Well, why is it necessary to go out into space? Why do we attach so much importance to this experiment?" asked Sergey Pavlovich, answering his own question: "I think there is a very easy answer to this question: while flying in space is it not possible to walk in space in much the same way, let us say, as learning how to swim after falling overboard in the ocean?

"This involves a whole series of operations, which may be required in the future during the rendezvous of spaceships. Working outside the spaceship greatly simplifies the task of performing special observations in space, well, and finally, it will be used in cases when something has to be repaired on the spaceship. For example, we give serious thought to the case when a cosmonaut, walking in space, must know how to perform all necessary repair operations, up to and including welding. This is not fantasy, it is necessity! The more people fly in space the more this necessity will be realized.

"Finally, we must also consider the factor that a situation may eventually come up, in which one spaceship must rescue another. But how? Indeed, the ships represent structures that are very well protected thermally, and therefore in terms of strength. One may approach a ship and be able to do, strictly speaking, nothing, because if he just breaks the seal around the entrance hatch, the people inside will die.

"Therefore such an airlock system, life support and exit system, providing a rescue capability, had to be developed."

The chief designer talks to us about the forthcoming first space walk outside of the spaceship, but he talks with such conviction that I believe he already sees large stations and observatories being assembled in orbit.

Sergey Pavlovich summarizes some results and turns his thought to the future:

"During the last short years, when so many space flights have taken place before our eyes, we changed to a different quality without being aware of it. Look: single-place ships flew, then came three-place ships, and now we are talking about a two-place ship. I venture to say right here that hardly anyone will fly single-place spaceships now. Hardly. And I think that I am not wrong in predicting the next step. Soon the question will arise as to how much sense it makes to launch into space for a few days such expensive systems as spaceships. Certainly they must be launched into orbit and left there for a long time.

"And these ships must be supplied and replacement crews must be sent up by simple spaceships, which of course must have an airlock in order to perform their functions, docking in orbit.

"This is how we unwittingly traveled down the road of qualitative evolution of our notions and of our directions of space exploration, in near-space for the time being, with orbital flights around the earth.

"That is, as a matter of fact, what I wanted to say, but I would also like to say that we are not trying to set any records. There is, of course, a reasonable risk involved. There always is and always will be. If for any reason, insignificant, I hope, because it seems to me that we have worked out and made provisions for all the basic contingencies, the unexpected arises, as can happen in any new endeavor, and the space walk will be risky, then..."

Sergey Pavlovich paused, thought awhile and continued:

"In that case the flight itself will still be valuable and important, because it is the flight of a two-place ship. We will extend it up to 2-3 days and a vast program of scientific and purely technological observations and measurements is available.

"Unlike all previous flights, this one is technically very complicated and laborious, businesslike, so to speak. It will be necessary to conduct a whole series of operations very quickly. The crew must first establish the flight procedure, which requires a certain amount of attention. Whereas we previously devoted the entire first orbit and the beginning of the second orbit to this matter, now only 2 minutes are set aside for it."

Sergey Pavlovich repeated: "Two minutes!"

"One hour after insertion in orbit," the chief designer continued, "we hope to hear the report that the cosmonaut made his exit from the spaceship and is conducting all his rather complicated assignments. He opens the hatch, climbs into the airlock, closes the hatch, gets himself ready inside the airlock, unseals the airlock, opens the outer hatch and makes his exit, in a word, as in that anecdote about a woman out of a bag, opens, closes and so on and so on..."

Everybody laughed. Then one of the journalists said quietly: "And what if? According to probability theory..." An uneasy pause followed. Sergey Pavlovich frowned. I then found out that Academician Korolev had not put to rest the thought of the risk associated with the space walk prior to the launch of "Voskhod-2." The meekly uttered unspoken question fell upon prepared soil. And Sergey Pavlovich calmly replied:

"Everything associated with space requires a lot of attention, comrades. A great deal of attention. Our systems are capable of performing in all possible combinations. If something goes wrong out there, then the cosmonaut, first of all, immediately finds out about it, and secondly he has ways to try to complete the operation with a backup system.

"That is, strictly speaking, the principle on which our program is based. Our flyers have been told: 'Don't take imprudent risks, but try to complete the mission.' If, let us say, the airlock hatch cannot be opened automatically, then open it manually, making sure that nothing is wrong other than, let us say, a defective electric drive.

"For example, we often turn on the light in a room, but the lamp does not light up. Then we hit the switch a couple of extra times, the lamp comes on and we forget about it. This is an important event in a spaceship! If a drive is turned on, but does not move, that means to stop! It must be examined to see what happened. Either try again, or perhaps switch to manual drive. I could give you many such examples. I should like to say that we have conducted an extensive preliminary debugging program here on earth. In fact, the State Committee today approved the completion of this program and its results..."

Sergey Pavlovich expressed an interesting opinion concerning the cosmonauts.

"I would point out the basic attributes of Leonov -- mental vitality. That is the first. The second is his great ability to master technical skills. The third is his flawless character. He is an artist, he himself sketches, is very genial, and in my opinion a very good and gracious man. He is a courageous aviator. He has a technically perfect ability to handle the modern jet interceptors. This man, it seems to me, is one on whom absolute reliance can be placed.

"As regards the flight commander, he has experience in command work and exhibits the same qualities as Leonov, but he was a squadron commander,

which means he has command experience. He is an extremely calm and patient person, even a bit slow, I would say, but extremely responsible. He is not a master of long and eloquent speech, but nevertheless he goes about everything he does, I would say, fundamentally. Such a combination, in fact, is necessary and reliable.

"The second crew, the backup, is also an excellent one. They are all comrades from the first group, from the first detachment, from which Gagarin and all the others were selected."

"How important is the new experiment in comparison with Gagarin's flight?"

"That was the first big, great step, but what lies ahead of us now will be, I would say, an extremely noteworthy step, a quantum jump. The space walk, like the first flight into space, represents an element of discovery."

The journalists were interested in the problem of the individual maneuvering of the cosmonaut, the possibility of his being separated from the ship.

"And why should he go very far from the ship?" interjected Sergey Pavlovich, "why walk between two trolleys or, let us say, between good automobiles, parked on different roads?

"Is there any need for that? To get out of a car to change a tire or simply to get a breath of fresh air, of course, is necessary, or to fix something, to talk with a neighbor, or, if you are stopped right next to another car, then you get out, talk, maybe get into the car next to you and sit down, or he in your car, but why should you wander about on unpaved roads? What need is there for that in space?"

This question seemed to disturb the designers. It is an important problem. The academician smiled. His eyes shown craftily. He was interested not in what the designers and scientists think about this subject, but the journalists...

"We may, of course, fantasize a bit here. Large ships, let us say, may be very close to each other without approaching. They are 10 kilometers apart. They can see each other only by electronic means. How, you ask, do you get from one ship to the other?

"Not, of course, in a space suit with an individual power pack with oxygen or any other propulsion. What is needed then is a space taxi, a space sloop to commute long distances. Because for weight, thermal, supply and safety considerations it is risky to flick a man, like a grain of sand, into space for a distance of 20 kilometers. Would it not be better to take a taxi? It should have the capability to see its own ship and the other ship, toward which it is traveling, and to return to its own ship. It must have communications. And in the event of any emergency situation redundancy and so on. And so it is easier, you see, to build some light vehicle, not influenced by the earth's gravity, which will enable you to move from one place to another!"

"Does that mean that this question has been discussed?"

"Well, I said that we were fantasizing," laughed Sergey Pavlovich. "We are discussing it right now with you, creatively participating in development. Some day it may be said that this thing was created at a press conference."

"Will the flight commander be able to help Leonov?"

"I can say that if Comrade Leonov runs into any trouble and becomes helpless at any time, the commander himself will leave the ship to rescue Leonov. Our "Voskhod-2" makes provisions for such a possibility. After putting the ship in the automatic guidance mode the commander can leave it and go to the rescue of a cosmonaut. It is also possible to depressurize the ship for a rather long time, which also greatly facilitates the functions of the crew."

Now, after the successful flight of Leonov and Belyayev, this question no longer seems so urgent. We know that the flight was completed safely. There wasn't even any stress or drama, so to speak.

Just the same it is very interesting, it seems to me, to trace the thinking of the scientist. Indeed, several different variations must be conceived. Everything must be anticipated.

Before hardware is placed in the hands of cosmonauts, it is tested in laboratories, in heat- and altitude chambers. Individual systems are tested up to 4,000 times.

This is ordinary research work. The assembly of the ship is proceeding and everything is in order. But suddenly an operator, sitting at a control panel, reports that a fuse blew out some fraction of a second after one of the systems was turned on. The system is rechecked. This means another delay. What nonsense! The fuse indeed blew! But no, they continue the studies and they check the circuits and documentation. They compare data and reach the conclusion that possibly one relay failed. This "possibly" means several hours of work. They remove the instrument and re-examine it. And space technologists have developed their own style of work: nobody leaves until the job is done. A circuitry failure occurred and everybody looks for it.

The chief designer speaks with great respect about the people with whom he works: "He who has a formal attitude to his work will not last long in the staff. Either he craves our work and becomes an enthusiast, or he falls to the wayside." Sergey Pavlovich asks us journalists not to forget the staff. He emphasizes that the age of individuals in science has ended.

"Once," he recalls, "I could solve all problems by myself. I can remember when an aircraft designer could make wings several centimeters longer or shorter. I could make all the decisions and do all the calculations by

myself. Now computers do it. The mind and love of labor are still important, but life poses such enormous problems that no one man, no matter how talented, can solve them alone."

The correspondent of KRASNAYA ZVEZDA asks Sergey Pavlovich to discuss the creative participation of the cosmonauts in the preparation of the spaceship. He asked the question without beating around the bush, so to speak: "Can cosmonauts be considered creators?"

Sergey Pavlovich paused, and then replied quietly, somewhat angrily at first:

"I admit that scientists, designers and engineers must solve the main problem. It is a difficult situation. It sometimes turns out that neither one nor the other sees the way to the solution. They argue. Eventually they arrive at the same opinion. In our work cases arise one after another when we argue and cannot reach a firm opinion. We never solve the problem by edict. I never use force. No one ever forces anybody to subscribe to a decision or instruction until everybody is convinced. Therein, in my opinion, lies the vital strength of all creative Soviet work forces. I know aviators and I know submariners. It seems to me that the same pattern holds true for them as for us. Our style is the same. No one says: 'This is mine and that is yours.' They say: 'This is ours.'

"Therefore my answer to you is this. The creative participation of the cosmonauts must be recognized, because that is valid and correct. Our aviators are unquestionably extremely creative participants in the preparation of the spaceship. But to say that they are creators? It is also incorrect to say that we are creators. We are par-tic-i-pants.

"If you think that the chief designer of any system or ship is the creator of that ship, you are confused. The chief designer has direct obligations, for which he is morally and legally personally and solely responsible. Take raw data, for example. Hundreds of people argue with him for 3 months. Then comes the time when these data must be confirmed.

"The chief designer, by law and by conscience, bears personal and sole responsibility for the confirmed data, for procedure and safety.

"Indeed, a job can be set up procedurally in such a way that not everything is anticipated and something does not get done, but you don't cheat life and that 'something' must come out! Can the chief designer alone foresee it? He cannot. That is the fruit of collective labor! The procedure must be worked out and all that is superfluous must be weeded out. You tackle the main problem, establish a routine and confirm it. It is for this that the chief designer, in contrast to the sculptor, bears personal and sole responsibility.

"I have a friend, a famous sculptor, a national artist of the USSR. We were talking once near the monument to Repin, which he had just done. Suddenly he said: 'Just a minute. Just a minute...'

"Nearby was some scaffolding made of rough old boards, unplaned, with some steps nailed to it. And this educated, erudite man suddenly scampers up these stairs, like a squirrel. He takes a mending chisel from his pocket and makes a mark on the sculptured face. He makes a mark, stops to look, and then makes another mark. He appears satisfied, returns the chisel to his pocket and just as quickly climbs down the ladder as though nothing had happened.

"What did he see? I looked and looked and saw nothing. It was an excellent sculpture! But he saw something while we were talking! Now that is individual creativity. Nobody helps him, of course. He does everything by himself. He sees his own Repin.

"Therefore it is not correct to speak of us as creators. We are participants."

The chief designer talks with fascination about the complexities of the design of various systems. Indeed, astronautics is an infant among the many sciences and sectors of technology. All the better, because developments in metallurgy and chemistry, electronics and automation are all incorporated in astronautics.

The scientist discusses the various possible versions of the space walk, offers his opinion as to why the decision was made to use the airlock system and tells how many tests the designers conducted before they approved the system.

He also talks about the space suit in which Leonov will walk in space and about the life support system.

One of the problems with which the designers of the space suit were confronted was how to combine the heat and cold. In space the temperature on the dark side is lower than in the coldest regions of the earth. It is higher than 100 degrees in the direct rays of the sun. A thousand more tests were conducted for the purpose of selecting the materials for the space suit. First individual parts were checked, and then the entire suit was checked in a thermal vacuum chamber at high and low temperatures under vacuum conditions.

A mannequin was built and tested on a centrifuge, on vibration stands and special machines for dynamic and static strength. If the tests went well the space suit was worn by test personnel and checked again on land, in the air and sea and in ice tanks.

Sergey Pavlovich talks at length about this:

"The space suit is a duplicated system with high reliability and strength, designed for specific operating conditions in space. The suit is a reliable shell, in which the cosmonaut lives. At the same time the system enables him to move about, bend his arms and legs, turn and perform all necessary maneuvers.

"The life support system maintains comfortable conditions, the same as inside the spaceship. This means that there is no particular stepdown here. Oxygen supply, blowing and ventilation of the space suit are all provided in accordance with strict health standards. Strictly speaking, therefore, life in the space suit under weightlessness conditions, in my view, does not threaten the cosmonaut with any complications if all systems work properly. As for living conditions inside the ship itself, they are excellent, as you know, in all of our spaceships. There is a lot of room, good fresh air, cold drinking water and excellent food, prepared to the taste of each cosmonaut.

"I do not know what our comrades have ordered, but they will certainly have all kinds of delicacies, like vobla."

"Is there an intercom system?"

"There is an intercom system for communications between the cosmonauts and between each cosmonaut and earth. In a word, they have complete service."

"How about television?"

"At the command center we will watch by television what is going on inside the spaceship, the cosmonaut's exit and activities outside of the airlock."

"And will this take place at the beginning of the second orbit?"

"Well, we assume so, nominally. But if any delays or uncertainties occur, then we are not tied to any time schedule and may try again in the next orbit."

Sergey Pavlovich looked at his watch: "I'll see you at launch!"[1]

Launch was 1 day away.

Today, as before, P. I. Belyayev and A. A. Leonov, exactly according to schedule, began the day with a physical workout under the physician's supervision. After breakfast we went in the same bus with them to the launch site, where more prelaunch training was scheduled. The cosmonauts were placed today under the care of the physicians. Immediately following their arrival they were taken into a specially equipped room, in which various instruments were set up. Sensors, which would transmit to the earth by telemetry data on the physiological condition and well-being of the cosmonauts, were affixed first to A. A. Leonov and then to P. I. Belyayev. The sensors must operate faithfully and precisely now as never before, especially those of A. A. Leonov, who would be experiencing special space flight conditions. Instruments back on the earth would have to receive through radio telemetric channels objective data about the condition of the cosmonaut. It was extremely important to know the state

[1]"Most v Kosmos" (A Bridge to Space), Moscow, Izd-vo Izvestiya, 1971, pp 229-241.

of the cosmonaut (his pulse, respiration frequency, electrocardiogram, etc.) before his exit from the spaceship, during his stay in open space and after the completion of this new experiment, which undoubtedly would provide new data on the influence of all space flight factors on the human body.

This is why so much attention was devoted to the performance of the sensors under laboratory conditions on the earth.

P. I. Belyayev and A. A. Leonov again tried on their space suits that day, but this time on special couches, installed in the room. These couches were exact replicas of those installed in the spaceship. The cosmonauts were surrounded by experts, who painstakingly checked each element of this quite sophisticated spaceoutfit. This was quite understandable, since a cosmonaut's space suit is actually his second spaceship in the event of depressurization of the cockpit of the spaceship. Such also was the case when the cosmonauts were flying inside the spaceship, and A. A. Leonov had to fly not only inside the ship, but also outside of it, i.e., in open space, at a great altitude and great velocity, equal to 28,000 km/hr. Therefore the space suit of a cosmonaut walking in open space had to be exceptionally strong and ensure the completion of this complex experiment. Like everything else, it was tested, modified, calculated and analyzed, but the technical supervisor again and again required his subordinates, who were getting the booster rocket, spaceship and cosmonauts P. I. Belyayev and A. A. Leonov ready for flight, to make repeated checks.

Everything is ready at last, and it is time to assemble at a technical conference, at which the results of the entire effort of many specialists to complete this difficult, time-consuming and laborious project will be summarized. The meeting of the State Commission will take place tomorrow.

At the designated time we are transported, along with the cosmonauts and a group of correspondents, to the launch facility, where the Commission will meet.

We arrive and after a short time we take our seats in the large hall of a three-story brick building. In front of us, at a long table, sit P. I. Belyayev, and A. A. Leonov. The assembly hall is filled to capacity. Technicians bustle about movie cameras, adjusting their equipment. At exactly 1600 hours, as scheduled, the chairman and members of the State Commission, Academicians S. P. Korolev, V. P. Glushko, cosmodrome officials and support service chiefs enter the hall.

The chairman of the Commission reads the agenda:

1. Report of the technical supervisor on the readiness of the booster rocket and spaceship for launch.

2. Confirmation of the crew of spaceship "Voskhod-2."

Sergey Pavlovich reported to the Commission that the preparation program is complete and that final operations are now under way. In conclusion he

said: "I move that the rocket and spaceship be placed in the launch position." N. P. Kamanin spoke on the second item and introduced a motion that the crew of "Voskhod-2" be confirmed. Turning to the chairman of the State Commission, N. P. Kamanin said: "Comrade Chairman of the State Committee! I move that Lt Col Belyayev, Pavel Ivanovich, be designated as flight commander of the spaceship 'Voskhod-2,' and that comrade Leonov, Aleksey Arkhipovich, be designated as the aviator-cosmonaut who will walk in space."

The committee members unanimously approved the items of the agenda.

Then P. I. Belyayev was invited to speak. He said: "Comrade Chairman and members of the State Commission! I wish to express my gratitude for the great confidence which you demonstrate in me byaappointing me flight commander of the spaceship 'Voskhod-2.' I shall apply all my efforts and knowledge to ensure that this great and important mission will be accomplished with honor." Then A. A. Leonov spoke: "Thank you very much for your great confidence in my ability to complete this flight and new experiment, involving a walk in space. I shall use all my powers and skills to complete the assignment. I feel great and I am ready for the flight."

Then Yu. A. Gagarin, the world's first cosmonaut, turned to his friends and said: "I am happy that you were selected for this mission. It will be a difficult and important flight. I know that you are completely ready for this assignment. All of us here on earth are ready to help you at anytime, should the situation require it. I wish you a successful flight and a safe return to earth. Good luck, my friends!"

The chairman of the launch command, who spoke at this meeting, congratulated A. A. Leonov and P. I. Belyayev on their confirmation and wished them success in the completion of the program, involving the making of direct contact between man and space.

S. P. Korolev gave the closing speech, saying: "My dear Pavel Ivanovich and Aleksey Arkhipovich! You have been called upon to perform an honorable and difficult task, to take a new step, to open the door to space for the very first time. The importance of this experiment is great. I wish you the best of luck and a safe and speedy return!"

After the meeting everybody congratulated P. I. Belyayev and A. A. Leonov on their confirmation. On that very same day, in accordance with the rules of the Sports Code of the International Aviation Federation, I got together with P. I. Belyayev and A. A. Leonov for the official prelaunch meeting and for the filling out of all necessary forms.

The meeting was held in the presence of representatives of the press, radio, television and motion picture industry. Aviator-cosmonauts Yu. A. Gagarin and V. M. Komarov were also present at the meeting.

Before the beginning of the meeting, on behalf of aviation sportsmen, I warmly congratulated P. I. Belyayev and A. A. Leonov on their confirmation

by the State Commission, one as the flight commander of "Voskhod-2," and the other as the aviator-cosmonaut designated to walk in space.

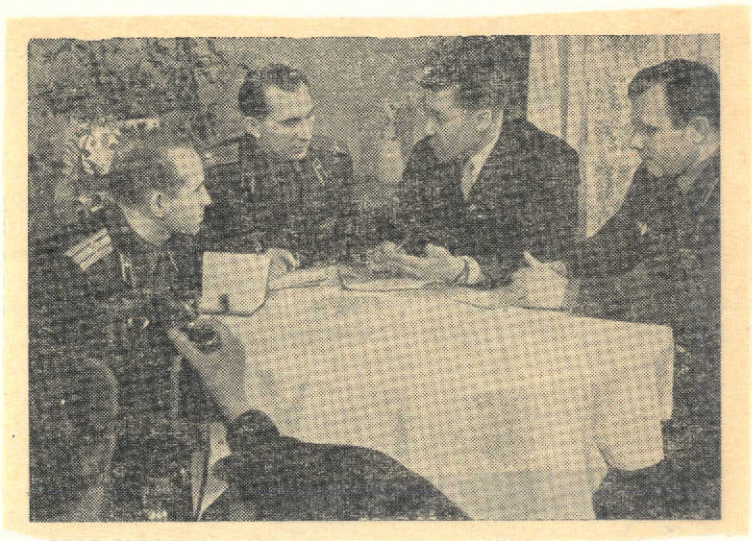

Figure 5. On eve of launch athletic commissar I. G. Borisenko explains to A. A. Leonov and P. I. Belyayev the rules of the "Sports Code of FAI." Yu. A. Gagarin participates in the meeting.

We then filled out a general information form, on which we gave detailed data about the cosmonauts and technical information about the rocket, the flight of the spaceship "Voskhod-2" and the completion by P. I. Belyayev and A. A. Leonov of the new scientific experiment, which was to be an absolute world record technical achievement in all respects.

I then explained to them that during the course of their flight aboard "Voskhod-2" they might set world records, the registration of which, unfortunately, is not yet provided by the existing Sports Code of FAI. "This is nothing unusual, my dear friends," I said to P. I. Belyayev and A. A. Leonov. "This is nothing new to Soviet aviator-cosmonauts, since through their flights everyone of them, from Yu. A. Gagarin to the "Voskhod" flight with the three-man crew, has brought about important changes in the position of the Sports Code on the registration of new space records. Now you, like your friends before you, will also have an opportunity to start a new category of records and, accordingly, to make necessary corrections in the code as the result of your flight." In conclusion I sincerely wished P. I. Belyayev and A. A. Leonov successful completion of the difficult scientific-technical assignment, the space walk, which would go down in world history as a great achievement of Soviet science.

Baykonur is one of the greatest cosmodromes in the Soviet Union. The world's first artificial earth satellite was fired on 4 October 1957 from its launch facilities, the world's first space flight by man, Yu. A. Gagarin,

started there and other Soviet cosmonauts have been launched into the expanses of the universe aboard "Vostok" and "Voskhod" spaceships.

The cosmodrome is a complex of installations, facilities and measuring centers, performing a great variety of functions and tasks. I should like to talk about one of them, the assembly-test building (MIK). It is an enormous building, located not far from the launch pad. In this building the spaceships and booster rockets are assembled and mated and all systems tests are performed. In the assembly-test building work many specialists, on whom depends so much, from the preparation of the most sophisticated systems, units, assemblies, booster rockets, launch systems and spaceships to the very launching of Soviet cosmonauts and automatic space stations and satellites into space.

Whenever I visit the cosmodrome before the launching of manned spaceships into space, I must go to the MIK in order to report all the required data about the rocket booster, spaceship and other information, which must be entered in the so-called "Records Affidavit." More than once I have had the opportunity to observe there, in that building, the entire technological process whereby spaceships and booster rockets are prepared for space flight. Once again I am in the MIK to witness, along with others, the creative and inspiring event of the transfer of a rocket and spaceship to the launch position.

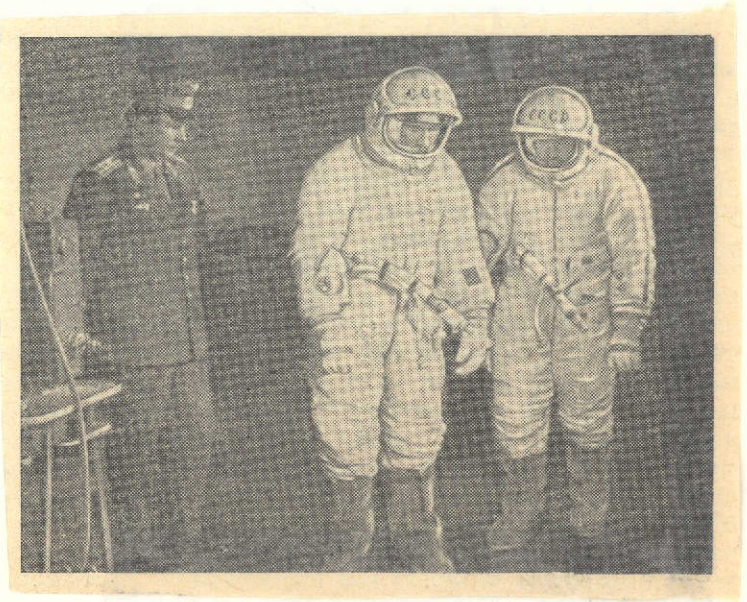

Figure 6. First cosmonaut Yu. A. Gagarin gives advice to crew of "Voskhod-2."

The "Voskhod-2" spaceship is now completely prepared for mating with the rocket, which sits next to it on a special platform. But it is still too early to do this task. Test stand measurements of all parameters of the rocket and spaceship must yet be conducted.

The spaceship is "clothed" in a fairing. At the same time the rocket, already completely prepared, is slowly moved toward the spaceship and is connected to it with fastening devices.

Little time remains to launch. Tomorrow the rocket and spaceship will be hauled from the assembly-test building to the launch pad. The people will remain with the rocket. Many things still must be checked.

During this time preparatory operations are under way at the launch pad to receive the rocket and to place it in position. Many tasks are performed there. Indeed, the launch facility service group has a great deal of equipment, which also must be checked. The complex consists of the following equipment: launch, transport-erection, fueling, mating-assembly, electrical power, test firing, fire prevention, etc. A launch group, the personnel of which undergo special practical and theoretical training and have the skills necessary to service this complex equipment, is responsible for the preparation and operation of each type of equipment.

Early the next morning we stand near the enormous door on the opposite side of the MIK. The door gates open slowly on both sides. Inside the building, on a special long platform, lies the rocket with the spaceship. A tractor slowly approaches the platform. Accompanied by the chairman of the State Commission, the chief designer of space rocket systems S. P. Korolev, cosmodrome personnel, journalists and support personnel, the tractor slowly pulls on the long platform behind it this unique technical creation of our century, the product of human intellect. More than once I have had the opportunity to witness this incomparable event, and somehow it always seems as though I am witnessing it for the very first time.

Sergey Pavlovich is there giving explanations to reporters and answering their questions.

The launch facility is located near the assembly-test building and the delivery of the rocket and spaceship takes place quite rapidly. The rocket and spaceship leave the MIK area and travel by rail to the launch facility. I sit in a car with S. P. Korolev and journalists and we drive to the launch facility. A few minutes remain before the arrival of the locomotive, pulling the rocket and spaceship. We walk around the launch site, accompanied by S. P. Korolev, and examine all its facilities. It is difficult to describe with words everything you see there, at this historic place, whence powerful rockets have ascended skyward numerous times, carrying Soviet spaceships and cosmonauts into space.

The service gantries, like the petals of a fantastic flower, lie on their supports around the vacant launch facility and are ready on command to embrace the rocket.

As we examined all the facilities at the launch site the long platform arrived, carrying the tremendous rocket and spaceship. The locomotive comes to a stop. By commands, which are constantly heard over the intercom,

powerful hydraulic jacks begin slowly to lift the rocket, placing it in position in the launch tower. Wandering around the launch facilities we observe the interesting work that the launch command performs diligently. One senses the great dedication of this remarkable staff to their work. Now special devices begin slowly to lift the rocket, atop which is perched the "Voskhod-2" spaceship. When the rocket is placed in the strictly vertical position all the service gantries begin slowly and with great care to surround it on all sides. The rocket, enshrouded on all sides by cables, with a set of scaffolds from which the launch command works, is ready for fueling. By radio commands the workers of the launch site quickly take their places on the scaffolds. They check the connections of all lines of the launch facilities to the rocket.

We leave the rocket and go down to look at the launch installation again. The view is a truly grandiose one. Beneath the rocket is an enormous pit with a race, designed to deflect exhaust gases when the rocket motors ignite. The floor and walls of this race are faced with refractory plates. It is deep and wide enough to easily accommodate a large multistory building.

Not far from the launch pad is a bunker, where the countdown is in progress. We enter the bunker and survey the equipment. It is from here that the launch is controlled. In all of the rooms of the bunker, deep under the ground, are installed various electronic and radio electronic systems, power units, control centers, panels with many buttons, levers and special lights. We examine for a long time and with great interest and attention the launch switch and ignition button, which have been turned on and pressed many times by experienced operators, launching rockets and spaceships. The prelaunch preparation countdown is made and the flights of rockets and spaceships are controlled here in interaction with measuring and computer coordination centers.

No matter what compartment or room we entered, we sensed everywhere a feeling of discipline, accuracy, competence, skill and precision. This is understandable, because there, where booster rockets and spaceships are prepared for launch and flight, where launch and the entire flight are controlled, there can be no mistakes in the operation of the equipment or in the actions of the people who perform these vital operations.

And so the rocket is poised. Now all that remains to be done are most important and responsible tasks, i.e., fueling of the rocket and checking of all systems of the ship and booster rocket.

On that same day, as always, 24 hours before launch, a meeting of all personnel of the launch command was held. At the base of the rocket, at exactly 1600 hours, scientists, designers, cosmonauts, journalists and launch experts assembled. The meeting was attended by the chairman of the State Commission and its members, S. P. Korolev and his aides. At 1550 hours a large blue bus arrives, from which emerge P. I. Belyayev and A. A. Leonov. They are met with thundering applause. Representatives of

the launch command and scientists spoke at the meeting, assuring the crew of "Voskhod-2" that the rocket and spaceship were ready for launch.

Then the crew members of "Voskhod-2" were invited to speak. Flight commander P. I. Belyayev said to those assembled there: "Dear comrades! I wish to express by sincere gratitude to our scientists, designers, engineers and launch command personnel for the great effort which they put into the preparation of the "Voskhod-2" spaceship for flight. I express special sympathy and recognition to the launch command personnel, to these remarkable workers, who have done so much for our flight. All of the spaceships which they previously prepared for flight for our cosmonauts, as we know, have performed well. We are confident and we know that our launch and flight will be successful. We shall endeavor, dear friends, to justify your faith. Thank you for your good wishes. Goodbye."

A. A. Leonov said: "Dear comrades! To all who are present here, and to those who are not present at this meeting, we are indebted for the trust which you have shown in us. We know that your technology with which we will accomplish the flight will not let us down. This is my fourth time at the cosmodrome, and I have witnessed the launches of Soviet spaceships into space. I am stirred not because tomorrow is the day of the launch, but because I am confident in your noble, responsible and honorable labor. You may rest assured that we will perform our assignment with honor. Thank you for everything, dear comrades. Goodbye."

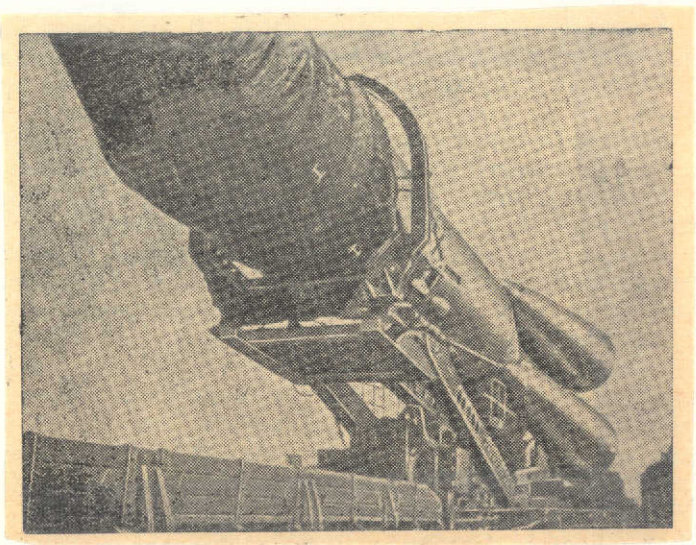

Figure 7. Rocket being towed to launch pad.

P. I. Belyayev and A. A. Leonov mingle to loud applause among all assembled at this prelaunch meeting.

Then they are lifted to the spaceship atop the rocket along with S. P. Korolev, who, in keeping with tradition, turns the "Voskhod-2" spaceship over to the crew.

We are then invited to go up to the spaceship, again to examine its cabin, in which P. I. Belyayev and A. A. Leonov will complete their stellar journey.

On that same day, after the official dedication of the spaceship, Pavel Ivanovich Belyayev and Aleksey Arkhipovich Leonov departed to the cottage for their prelaunch relaxation and medical examination. By tradition, Yu. A. Gagarin, G. S. Titov, A. G. Nikolayev, P. R. Popovich, V. F. Bykovskiy, V. V. Tereshkova, V. M. Komarov, K. P. Feoktistov and B. B. Yegorov stayed in the same cottage before their flights into space.

The "Voskhod-2" spaceship will be launched tomorrow by resolution of the State Commission.

Early in the morning of 18 March I go with the correspondents to the launch site. P. I. Belyayev and A. A. Leonov have already arrived. The physicians have begun to affix sensors to them, and now specialists are helping them into their uniforms and space suits. V. M. Komarov, K. P. Feoktistov and B. B. Yegorov only took a few minutes to don their space jackets and trousers, but the crew of "Voskhod-2" requires much more time for this. As much time was spent on getting them into their space suits as all the other cosmonauts who completed their space flights aboard "Vostok" ships. Finally the sensors are in place and the space suits are on. A check shows that everything is in order. Now theymmay board a special bus and go to the launch pad to take their seats in "Voskhod-2."

The correspondents and I accompany the cosmonauts. After riding for several minutes we arrive at the rocket, which stands poised for flight.

It snowed all the night before the launch. The steppes around the launch site are white. Snow lies on the top of the spaceship, on the service gantries and on work scaffolds.

The bus arrives. From it step P. I. Belyayev and A. A. Leonov in their white space suits. On the front of their space helmets are clearly painted in bright red the letters "SSSR."

At the launch pad the cosmonauts are met by the chairman and members of the State Commission, S. P. Korolev, designers, Yu. A. Gagarin and B. B. Yegorov. The cosmonauts walk slowly across the snow-covered concrete slabs. "Voskhod-2" flight commander P. I. Belyayev walks up to the chairman of the commission and reports in military fashion: "Comrade Chairman of the State Commission! The crew of the spaceship 'Voskhod-2' is ready for flight. Flight commander Lt Col Belyayev." S. P. Korolev and the chairman of the State Commission, and then Yu. A. Gagarin, V. M. Komarov and B. B. Yegorov embrace the cosmonauts and wish them a good flight and a safe return to earth. We also wished P. I. Belyayev and A. A. Leonov good luck in their new, interesting and important flight.

It is now time for the cosmonauts to take the elevator up to the spaceship. A. A. Leonov goes first. Before entering the elevator he waves his hand

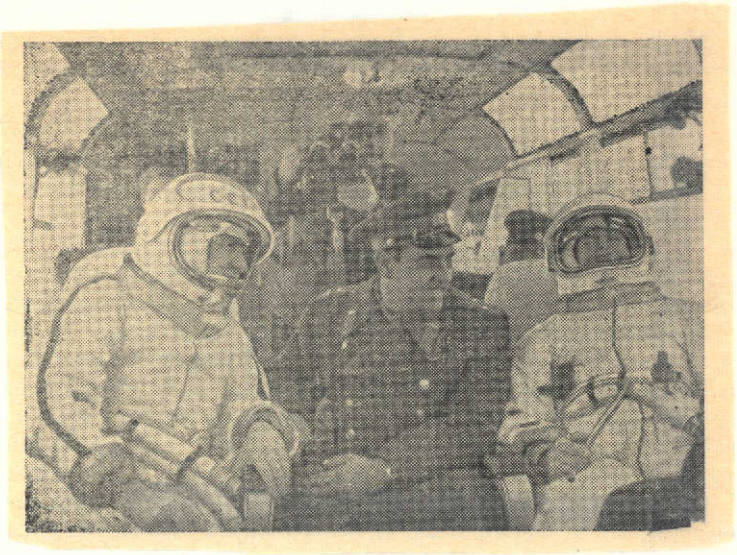

Figure 8. A. A. Leonov, P. I. Belyayev and cosmonaut V. M. Komarov riding in bus to launch pad.

to all. The elevator delivers him quickly to the spaceship. Then P. I. Belyayev ascends. The cosmonauts stop on the top platform and wave their hand. P. I. Belyayev and A. A. Leonov, with the aid of specialists, take their places in the spaceship.

The launch pad is abandoned. Some people go to the command center and others go to the observation point. As before, we go to a place from which the rocket and spaceship can be seen very clearly. It is the observation platform. A television monitor, external electronic systems and optical instruments are even set up there.

The announcement "T minus 30" is heard over the intercom.

"Almaz, this is Zarya. How do you read me?" asks Yu. A. Gagarin of P. I. Belyayev.

"Zarya, this is Almaz," replies Belyayev. "I read you fine. Everything is normal. Humidity 40%, cabin temperature +10°."

Then A. A. Leonov enters the conversation and reports to Yu. A. Gagarin: "I feel fine, ready for flight and completion of mission."

I keep looking at my watch. The countdown is in the last minutes.

"T minus 15!" is announced.

The servicing personnel leave the launch pad. I see the fueling, and then the cable towers separate from the rocket. All direct communications between the onboard systems of the spaceship and rocket and the ground

are severed. They are placed on automatic control and internal power. During this time the launch system holds the rocket with its mechanisms.

The countdown proceeds.

S. P. Korolev speaks to the crew over the radio: "I wish you the best of luck. Goodbye and good luck."

Aboard "Voskhod-2" P. I. Belyayev and A. A. Leonov are informed over the radio that the Central Committee CPSU just called and wished them a good launch and flight and a safe return to native Soviet soil. The "Voskhod-2" flight commander P. I. Belyayev replied over the radio: "Many thanks for these warm wishes."

The second hand sweeps through the last minutes of the countdown. All present fix their gaze on the rocket, which is now separated from the service gantries and ready to lift the spaceship "Voskhod-2" with the cosmonauts aboard to the prescribed altitude.

"Almaz, this is Zarya. Don't worry, stay calm," advises Yu. A. Gagarin.

"Zarya, this is Almaz," replies A. A. Leonov. "Why should I worry? Lying here thinking, this is the life."

V. M. Komarov joins in the conversation with the crew of "Voskhod-2," wishing P. I. Belyayev and A. A. Leonov complete and successful fulfillment of the flight program.

The clock reads 0955 Moscow time.

"T minus 5!" is announced.

P. I. Belyayev reports from aboard the ship that everything is in order and that they are ready for launch.

The second hand sweeps relentlessly, ticking off the final seconds.

The television monitor clearly shows the faces of the cosmonauts. The final prelaunch commands are transmitted via the radio relay network.

"Stand by -- T minus 1!"

"Almaz, this is Zarya. Stand by -- T minus 1!"

From the bunker, in which the control center is located, is heard the clear and authoritative voice of the launch commander: "Switch to launch!"

The timing mechanism of the control center is turned on. At this point the launch time will correspond to the calculated time to an accuracy of hundredths of a second.

"Roger, switch to start!" replies the operator.

"Pull down one!"

"Roger, pull down one!"

"Vent!"

"Roger, vent!"

"Switch to exhaust!"

"Roger, switch to exhaust! Exhaust OK!"

"Ignition!"

"Almaz, this is Zarya. Ignition!"

P. I. Belyayev replies:

"I understood you, ignition."

"Preliminary!"

"Roger, preliminary!"

During these final seconds all present on the observation platform fix their gaze on the rocket in anticipation of its separation from the launch pad.

"Intermediate... Main!"

"Liftoff!"

A deafening roar is heard. A column of smoke billows in all directions from beneath the rocket. Then a blinding flame bursts forth almost instantaneously from the nozzles of the rocket engines. The roar increases sharply and builds up. The air vibrates like a tightly drawn string.

The clock, which lies on a table, slowly slides away from me. The rocket, trailed by a bright plume of flame, slowly separates from the launch pad. I take my stopwatch and press the button. The second hand stops on the number "12." 10 hours 00 minutes 00 seconds Moscow time.

Already the rocket has reached a great altitude and with its bright flame plume slices into the clouds and vanishes from view. Then it reappears several times for an instant in openings in the clouds. The roar and vibration blend as a single continuous noise and then slowly fade away. Dead silence surrounds the launch pad. "Voskhod-2" is now at a great altitude.

"Almaz, this is Zarya. Everything is going excellently. All parameters are holding steady. Have a good trip," is transmitted from the command center to "Voskhod-2."

"Zarya, this is Almaz -- roger. I see the earth. The sky is very, very beautiful. The flight proceeds normally. We feel excellent," replies P. I. Belyayev.

The sound of the rocket engines vanished long ago, but people continue to stand around, as though waiting for a new launch.

"Almaz, this is Zarya. How are the g-forces?"

"Zarya, this is Almaz. Everything is fine, g-forces are light," replies flight commander P. I. Belyayev.

Some time passes and the spaceship reaches the prescribed altitude.

On the monitor we see P. I. Belyayev and A. A. Leonov, who are busy with their work.

Stable short-wave and UHF communications are maintained with the cosmonauts.

We go to the command center, where by now all necessary preliminary flight data of "Voskhod-2" have been determined. We are informed that the maximum flight altitude is 497.7 km. The orbital period of the spaceship is 90.944 minutes.

As soon as "Voskhod-2" reached the altitude of 497.7 km it was clear that its crew had set their first absolute world altitude record. This altitude had never been reached before by any spaceship with a man aboard.

At 1108 hours all present heard with great emotion the TASS announcement concerning the flight of "Voskhod-2."

"VOSKHOD-2" IN SPACE

The command-tracking complex, consisting of many tracking stations across the USSR along the flight path of the manned spaceship, went to work immediately after the launch of "Voskhod-2." The tracking stations are equipped with various types of television and electronic systems, which are used for telemetric measurement and monitoring of the health of the cosmonauts, conditions inside the spaceship, operation of the ship's guidance system, airlock, manual control, conversation and various instruments and structural parts of the ship, and also for measuring the level of cosmic radiation in the cockpit. Data obtained from monitoring and from orbital measurements during the flight of "Voskhod-2" were processed by computers, installed at the tracking stations and at the coordination-computer center (KVTs).

It was transmitted through telemetric channels, in particular, that P. I. Belyayev's pulse rate during the prelaunch period was 80 beats per minute, and A. A. Leonov's was 86. In the orbital insertion segment of the flight the pulse rates were 86 and 90, respectively, and in orbital flight (1st orbit) they were 92 and 95.

The exact flight altitude of the ship and its velocity were determined. The velocity of the ship in the 1st orbit at the apogee of 497.7 km was 7.31 km/s.

After "Voskhod-2" was launched we went to the command center, where we watched the flight of the ship and Leonov's space walk by television from beginning to end.

During this flight the crew of "Voskhod-2" had to complete the following scientific-technical research program.

Flight Program

1. Launch of rocket and "Voskhod-2" spaceship satellite at 0700 hours Greenwich Mean Time, 18 March 1965.

2. Flight of 16 orbits around the earth and landing in the USSR at 51° north latitude. Landing to be accomplished with automatic guidance system if flight proceeds normally.

3. In the second orbit the copilot performs a space walk and several experiments in accordance with the flight assignment.

4. In the event one of the crew members feels poorly or any system of the spaceship fails, early landing may be accomplished with the automatic system or by means of manual control.

The decision to make an early landing with manual control is made after consultation with earth. In the absence of communications with the earth the decision to land may be made independently by the flight commander.

5. The commander and copilot conduct HF and UHF radio communications throughout the flight. UHF communications are maintained within the range of UHF stations. HF communications with the earth are conducted every half hour Moscow time.

The broadcast receiver is used at the flight commander's discretion.

6. During orbital flight the crew members of the spaceship perform the following functions:

FLIGHT COMMANDER:

monitor and observe instruments;

monitor, observe and perform all necessary actions associated with the copilot's space walk and his return to the ship;

perform manual orientation of the ship; determine time of orientation, propellant consumption rate, time required for stabilization, ease of orientation and convenience of operation;

conduct radio communications with the earth and with the copilot during his space walk and return to the ship;

monitor the operation of the ship's systems;

conduct observations of the earth's surface at various times of the day; conduct still and motion photography;

assess feasibility of visual and astronomical navigation;

make notes in ship's log and on tape recorder.

COPILOT

conduct radio communications with the earth;

monitor equipment and parameters of ship's systems;

perform along with the flight commander all operations required for checking and preparing systems associated with space walk;

accomplish space walk, perform assembly and dismantling operations, conduct communications with flight commander;

analyze work conditions for man during exit from the ship, during the space walk and re-entry into the ship;

correct chronometers and perform "Globus" synchronization by instructions from earth;

conduct observations and studies from the cockpit during orbital flight, conduct still and motion picture photography.

In addition the crew members perform the following functions during orbital flight:

take food and water 4 times, evaluate features of eating, use sewage disposal system and sleep alternately;

carry out scientific research program;

conduct vestibular and psychological tests, do physical exercises and perform medical self-examination.

Observe and monitor the functional condition of the body during the space walk.

After firing the retrorocket the flight commander reports to earth about the operation of the system.

After re-entry into the dense layers of the atmosphere (after descent from orbit) the spaceship, with the crew aboard, completes landing.

After landing, the crew examines the ship, the flight commander reports the landing and the condition of the crew members.

This flight program was examined and approved by the Presidium of the Federation of Aviation Sports of the USSR.

The flight of the spaceship "Voskhod-2" continues.

Two-way radio communications is maintained continuously with the ship. Cosmonauts P. I. Belyayev and A. A. Leonov begin to work in accordance with the research program. All systems of the ship are operating normally.

At the end of the first orbit the crew begins to conduct preparatory operations for the space walk.

"Well, Lesha, shall we begin?" asks Pavel Belyayev.

"Let'ssbegin," Leonov replies.

Leonov unbuckles the seatbelt and Belyayev helps him put on the backpack life support system and oxygen supply. He then connects it to the space suit. Belyayev fills the airlock. Thus the gas composition of the air and the pressure in the cockpit and airlock equalize. After that all systems of the airlock and ship are checked.

Convinced that everything is normal, the commander presses a button and the hatch to the airlock begins to open slowly. When the hatch is completely open Leonov looks into it and sees there the light from frosted lamps, a movieccamera and the control center from which he can independently control the airlock system.

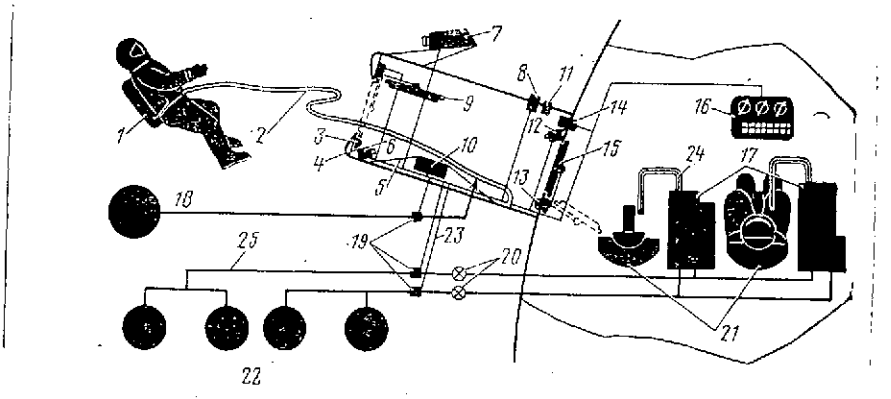

Figure 9. Diagram of airlock system and life support system [12]: 1 -- cosmonaut's self-contained life support system; 2 -- safety tether with communications and telemetry wires; 3 -- light; 4 -- hand grips; 5 -- manrope; 6 -- movie camera; 7 -- movie camera; 8 -- airlock pressure release valve; 9 -- electrically driven airlock hatch cover; 10 -- duplicate airlock control panel; 11 -- airlock safety valve; 12 -- movie camera; 13 -- light; 14 -- airlock-cabin pressure equalization mechanism; 15 -- electrically driven hatch cover of spaceship; 16 -- exit system control panel; 17 -- shipboard life support units for cosmonauts in space suit; 18 -- independent airlock pressurization system; 19 -- electrically controlled valves; 20 -- air pressure gages; 21 -- cosmonauts' couches; 22 -- space suit and cockpit pressurization system; 23 -- electrical wiring; 24 -- oxygen; 25 -- air.

The flight commander gives Leonov the command to begin the airlock routine.

Leonov rises above the couch. He now begins to experience weightlessness. He easily "swims" into the airlock chamber and holds himself steady for awhile. He builds up the required pressure in his space suit, checks its

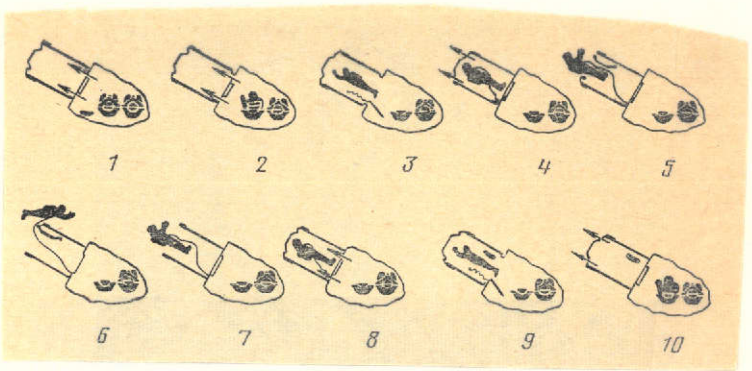

Figure 10. Diagram explaining cosmonaut's exit from spaceship through airlock chamber [12]: 1 -- airlock pressurization; 2 -- cosmonaut prepares to enter airlock. Backpack placed on; 3 -- cosmonaut enters airlock; 4 -- main hatch closed and airlock pressure released; 5 -- cosmonaut makes exit from airlock; 6 -- cosmonaut outside of ship; 7 -- cosmonaut re-enters airlock; 8 -- airlock pressurized; 9 -- main hatch opened and cosmonaut re-enters cockpit; 10 -- airlock pressure released.

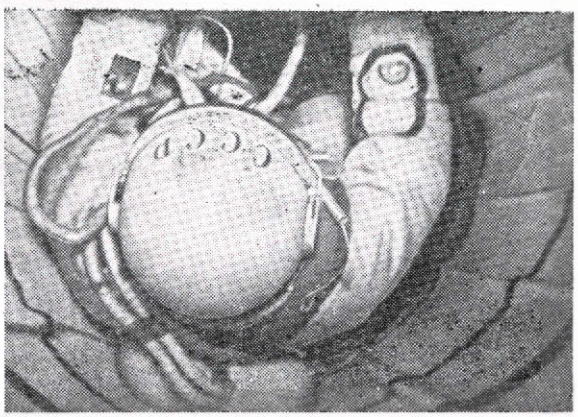

Figure 11. A. A. Leonov in airlock before space walk.

seal, radio communications with the flight commander, secures his space helmet and light filters and admits oxygen from cylinders in the backpack. Leonov completes all preparatory operations for going into space from the airlock chamber (AC) with time to spare. He is eager to accomplish his exit into space.

"Everything is normal. Ready for exit," he reports to Belyayev.

"You're early, Lesha," Belyayev replies to Leonov by intercom.

The flight commander once again checks Leonov's condition, instrument readings and the operation of all systems associated with his space walk.

Shortly before the outer hatch of the airlock chamber is opened Leonov's pulse rate reaches 100 beats per minute. His pulse rate was the same during training exercises under vacuum conditions in the thermal vacuum chamber. While Belyayev was doing the hardest preparatory work (more than 30 radio telephone conversations with Leonov, 2 long reports to earth, a flight path check, admission of oxygen into the airlock, switch to manual control, monitoring by gages of the actions of the copilot and many other operations), his pulse rate also reached 100 beats per minute.

This is indicative of the fact that these two brave men endured during that time not only great physical stress, but also great concern for the fate of this important experiment.

This was especially true of A. A. Leonov, who was aware that he would be the first man ever to go into outer space. To remain calm under these conditions, of course, was simply impossible.

"Prepare to exit!" says Belyayev, closing the inner hatch.

Leonov remains in the airlock. He examines the tether, which is 5 m 35 cm long. One end of the tether is fastened to the space suit, and the other to a notch in the airlock.

At 11 hours 28 minutes 13 seconds P. I. Belyayev releases the pressure in the airlock, i.e., completely unseals it.

At 11 hours 32 minutes 54 seconds the hatch of the airlock is opened. From this moment on A. A. Leonov is in deep cosmic vacuum.

I offer below an excerpt of the radio conversation that took place during Leonov's space walk:

"Leonov: The hatch of the airlock is open. I see light. The AC hatch is gone. AC hatch is completely open!

Belyayev: I understand, understand. Zarya-4, this is Almaz. I hear you. Almaz-2, AC hatch just opened. AC hatch opened. Everything proceeding normally! Everything is fine! This is Almaz, over. Lesha, report. How are you doing, Lesha?

Leonov: Everything is fine. I am now at the exit.

Belyayev: Almaz-2 has started exit. Is the movie camera on?

Leonov: Roger. This is Almaz-2. I am removing the cap. Casting off. The Caucasus! The Caucasus! I see the Caucasus below me! I've started out! (At that instant Belyayev declares to the world: "Man has entered cosmic space!" -- I. B.).

Belyayev: This is Almaz. The shifting of weight is affecting the ship.

Leonov: I'm out, I'm out! I'm approaching the hatch!

Belyayev: Good, good! I see you fine!

Leonov: I'm starting out again. Man's position seems to have an effect on the ship.

Belyayev: This is Almaz. Cosmonaut's departure from ship affects the ship as a whole... Good, you've gone out, how are you, Lesha?

Leonov: Excellent! Excellent!

. . . . . .

Belyayev: Two minutes left!

Leonov: Yes, yes! Now! I can't remove the movie camera.

Belyayev: Prepare to enter.

Leonov: Roger! Roger! I've got the movie camera, I've got it!

Belyayev: Almaz-2 feels fine. He is entering the airlock. He has the movie camera. Lesha, relax! Don't say anything! Have you re-entered the airlock?

Leonov: I'm in! I'm in!

Belyayev: Report when you are ready to close the hatch.

Leonov: You may close the hatch.

Belyayev: I'm closing the AC hatch. Closing AC hatch!

Leonov: It's closed. The hatch is closed.

Belyayev: Vesna, Zarya! This is Almaz. Almaz-2 is in the airlock. AC hatch is closed. Everything normal. This is Almaz. Over."[1]

Here are some of the notations the cosmonauts entered in the ship's log. I offer the following excerpts from the ship's log:

"Page 40. Orbit No. 2. Leonov, A. A.: During transit I was clearly aware of the position of my body in space... I was in the airlock during the beginning of orientation. I did not sense the rotation of the ship either at the beginning or at the end of orientation.

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[1]A. A. Leonov, B. I. Lebedev, "Psikhologicheskiye Osobennosti Deyatel'nosti Kosmonavtov" (Psychological Features of Activities of Cosmonauts), Moscow, Nauka, 1971, p 40.

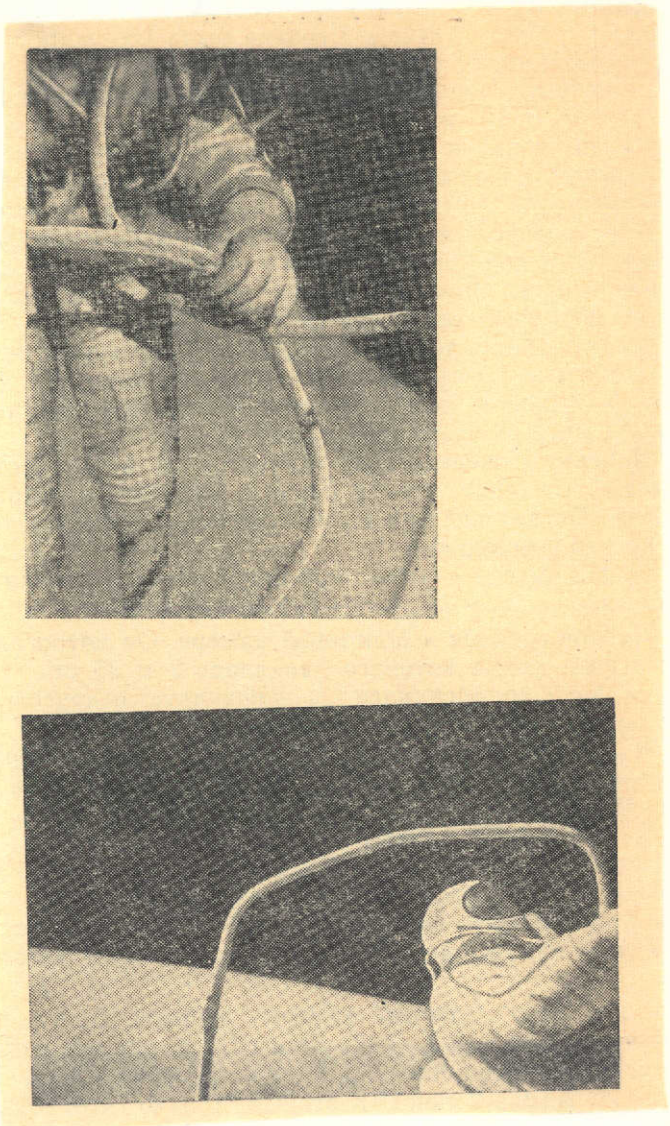

Figure 12. A. A. Leonov in outer space (frames taken by movie camera).

"Page 63. Space walk, space suit, KP-55 oxygen instrument. Volga.

launch g-forces -- excellent;

local unpleasant sensations -- none;

ease of strapping on of KP-55 -- easy;

opening of hatch of LV (launch vehicle) -- excellent;

switchover from B_2 unit and conversion of AC (airlock) to O_2 -- easy;

transit from LV to AC without difficulty. Commander guided backpack; moved easily through LV hatch;

check of seal of SS (space suit) -- tight. Pressure drop p = 0.01 at;

AC pressure release, feeling -- felt fine;

opening of AC hatch -- opened very fast. Illumination of airlock increased as hatch opened;

illumination of AC with light filter -- satisfactory;

without light filter -- excellent;

hatch cover closed -- satisfactory;

hatch cover opened -- excellent;

passage through AC hatch -- no difficulty.

"Page 64. Position after exit from AC.

transfer of S-97 movie camera to far bracket -- not done;

first exit -- went out to length of tether without twisting;

pushoff effort -- very slight;

sensation of jerk from tether -- no;

effect of tether on movement outside AC -- no effect on feel, has effect at end;

photography -- did not photograph;

removal of S-97 -- easy;

entry into AC (tether bay) -- tether easily brought in, on latch hook;

closing of AC hatch -- quick, smooth;

removal of backpack -- easy;

entrance into LV -- turned around in airlock, entered LV headfirst, turned around again and entered easily;

removal of "Vzor" cover -- easy;

reconnection -- easier than in simulators.

Figure 13. World's first cosmonaut Yu. A. Gagarin and cosmonaut A. S. Yeliseyev.

"Page 65.

evacuation of connecting cord -- quick, without ends;

mounting of movie camera -- difficult. Had to remove gloves and turn facing LV in airlock;

density of light filter -- normal, everything visible;

illumination -- did not come on, completely off in space K, performed operations without difficulty;

work with light filter -- difficult, but possible.

Temperature and ventilation

a) in LV -- adequate, even cold

b) in AC -- normal conditions;

c) outside AC -- normal, did not even perspire;

d) during re-entry into AC -- hot because of work.

use of oxygen in AC, outside AC -- not used;

initial backpack pressure -- 197 at.

final backpack pressure -- 155 at.

"Page 66.

pressure drop in AC after 7 minutes -- virtually unnoticeable;

pressure in AC after passage from LV -- after 5 minutes in open space went to pressure of 0.27.

Mobility increased.

Felt excellent. Oxygen supply excellent. Hands got very tired during exits and approaches."[1]

At 11 hours 34 minutes 51 seconds A. A. Leonov stepped from the airlock into space. When the airlock hatch was opened and as Leonov made his exit into space his pulse rate increased sharply to 150-152 beats per minute, and his respiration frequency reached 31 per minute. These changes were due primarily to higher physical and neuro-emotional stress. It is also noteworthy that the temperature of the space suit on the sunlit side was +60°C, in the shadow it was -100°C, and inside the space suit the temperature was +18°C.

A. A. Leonov, all alone in space, saw before him the deep black sky. The stars were brilliant, but they were not pulsating or twinkling and the sun was unearthly, without a halo.

He removed the lens cover from the S-97 movie camera and tossed it toward earth. He then began to carry out the scheduled observations and experiments. Heccompleted five departures and approaches in space, the first of which was to the minimum distance of 1 meter for orientation in the new conditions. During the first walks his body turned sideward and backward, but during the subsequent walks he did the exercises correctly and reliably, indicating his adaptation to the unusual situation in space.

Belyayev constantly observed Leonov's activities in outer space. Convinced that Leonov was having no trouble, that he was completing the program with composure, precision and competence, Belyayev reported to his friend by radio: "Everything is fine, Lesha! Your pulse and respiration are good. You are walking beautifully!"

While A. A. Leonov was outside the spaceship he heard the voice of announcer Levitan, who broadcast over Moscow radio the TASS communique about the launch of "Voskhod-2" and his walk in space.

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[1]A. A. Leonov, "Steps in the Universe," AVIATSIYA I KOSMONAVTIKA (Aviation and Cosmonautics), No 5, 1966, pp 27-31.

Time passed quickly. The final minutes of Leonov's adventure in space were coming to an end. It was time to go back to the ship, where Belyayev patiently awaited him. Leonov did everything he was required to do. He did not waste a single second. Above the Yenisey P. I. Belyayev instructed Leonov to end the experiment and to prepare to re-enter the airlock.

Leonov began to carry out the order. He removed the movie camera from the outside of the airlock and attempted to thrust it into the airlock. But the camera sprang back toward Leonov. He held onto it using great effort. Hanging onto the edge of the airlock with his left hand, Leonov sensed that he was being lifted upward. The cosmonaut then pulled himself toward the airlock with both hands and managed to get both his legs in it. He held the reluctant movie camera between his legs. Then Leonov entered the airlock. This took place at 11 hours 47 minutes 00 seconds. One minute 40 seconds later the hatch cover of the airlock was closed behind Leonov.

The cosmonaut had to exert considerable physical effort to return from space and take his place in the ship. Actually Leonov was in open space at 11 hours 28 minutes 13 seconds, when the airlock was completely unsealed. This unprecedented scientific experiment continued to 11 hours 51 minutes 54 seconds, when pressurization of the airlock was begun after the cosmonaut returned to it and the hatch was closed behind him.

Thus Aleksey Leonov spent 23 minutes 41 seconds in outer space. The time A. A. Leonov spent outside the spaceship was 12 minutes 09 seconds.

Here are some of A. A. Leonov's impressions about his space walk and the experiments he did.

"I am often asked if I experienced any unusual uneasiness or if my heart skipped a beat when I walked in space. I answer truthfully that nothing like that happened. I didn't even feel a chill inside me. I felt nothing but levity and freedom. I experienced only the most pleasant sensations -- greater than ever before. Perhaps I have disappointed you. Thus, you ask, I take such an unusual step (they write everywhere: the door to the universe is opened) without any apprehension? Why did everything go so smoothly, without any surprises?

"I cannot say, of course, that I felt no concern whatever. That would be incorrect. My pulse sped up a little. But that, evidently, is the same kind of reaction one would experience doing unusual work without even noticing it. In other words it is a common reaction, inherent to all people. In general, as I recall, I was completely collected, cool and relatively calm.

"In my opinion, the most important reason for my coolness (though I am anything but cool in nature) was my complete preparedness to go out into open space. I am talking about my training on earth. I could go on and on about how and where we trained. But I will say briefly that it consisted of two stages. The first was general physical training, including

diving, sky diving, acrobatics, batud exercises, jogging, in a word all types of sports associated with exercising of the organs of equilibrium and the vestibular system and separation from terra firma. All of this was good training. All of our cosmonauts take it. The second stage consists of special training, including numerous flight and simulator tests, weightlessness in an airplane, exercises in a thermal vacuum chamber, practicing of individual parts of the walk and of the entire experiment as a whole... We rehearsed the flight. It was hard work, but it paid off in spades. First it gave us confidence in the experiment. Second, it taught us precision and consistency. I did almost everything exactly the same in space as during the training exercises, without departing from the established order. This was most important.

"There is also another 'secret': I was so fascinated and captivated by the panorama of cosmic infinity that I had no room in my soul for any other feelings. I had just enough time to look and to complete the program. The greatest sensation I experienced in space was the stunning strangeness of it. My impressions of space were based on the stories of my comrades, but as the saying goes, it is better to see it once with your own eyes than to hear about it a hundred times. I saw the boundless expanses of the earth, one-half of the globe, and our side of it, from the Black Sea to Sakhalin. And not from a narrow view port, but from open space, a big three-dimensional view. I have already said that I got out of the spaceship over the Black Sea. How beautiful it was! I love the Black Sea. I love it in all weather. I used to sit for hours on the beach watching the changes of the colors. The water does not look the same from high above as it does from the beach. It is of the same color, deep blue, changing to steel blue. The sun is obviously 'guilty' of this by depriving the water of color. I spotted a ship in the open sea. In some science fiction book, I recall, the hero saw a fleet of ships from space. They all cast dark shadows on the water. I did not see any shadows, because the ship was illuminated uniformly on all sides by the sun. It appeared to be sailing in a sea of light.

"You see many more colors in space than you do on earth. These colors can also be seen on earth, of course, but they are not as bright. I was fascinated by the sunset. Wherever I looked, to the right, the left or upward, there was blackness. But between the earth and the sky there was a glow, a lovely pale yellow band. It was an alarming sight. Reminiscent of paintings by the artist Kuindzhi. But more distinct, contrasting, and perhaps more powerful in color. 'Cosmic nature' is a peculiar world.

"Above the Kuban expanses I 'met' Yuriy Gagarin in space. He asked me with concern: 'How do you feel?' I replied 'I see so much. It is difficult to say right now.' Yuriy laughed. Ask me about how I feel and I would say 'I see so much...' I am overwhelmed by my impressions. Yuriy did not repeat his question: he understood my rapturous feeling. We are old friends. We understand each other well. When Yuriy was flying I also 'met' him in space. And I also asked how he felt. He answered smilingly: 'Hello, my fair friend.' I remembered this and I now said:

'Greetings to all. And my personal greetings to the lilies of the valley.' We jokingly call our cosmonaut comrades lilies of the valley. It was not only a greeting, but also an expression of gratitude. The entire corpsoof cosmonauts, under the supervision of Yuriy Gagarin, prepared us for flight. Each one of them knew his business: he who helped us in the simulators, he who drove to a design office or to a plant to 'coordinate or test' something there, he who explained to us how to fill out our ship's log... All treated our flight as their own, without regard to who would be flying, we or they. Now it is my turn! I have a chance to say a warm word to my friends. And I, from my soul, sent my sincere greeting from space. Yuriy perceived it in his soul (and I have already said that we enjoy a special relationship) and replied: 'I understand. Thank you.'

"In space there is dead silence. Sounds, in fact, propagate as a result of vibrations of molecules in the air, of which there is none in space. I must admit that I was practically unaware of this cosmic silence; I didn't have time, so to speak, to sink my teeth into the cosmic silence. What it is like I really don't know. My familiarity with it is a distant one. I was talking with Pavel and was reporting to him everything that I could see from space, and I maintained communications with the earth through the spaceship. During these 10 minutes space was filled with noise. My voice alone was blaring like a trumpet! Then Pavel and I laughed: 'We have disturbed the cosmic silence with such a hullabaloo.' Imagine how many voices will be chattering out there in 2-3 years. The solemn silence of space will retreat into the back alleys.

"Nor was I aware of the tremendous speed of the spaceship or of my flight along with it. The spaceship seemed to hang in the cosmic void. When you are driving your car on earth you get an idea of your speed judging by trees and buildings as they flash before your eyes. When you close your eyes you still sense motion by the sound of the engine and vibrations. But in space nothing flashes by. The spaceship is silent, and only Pavel's voice is transmitted from it. To me the spaceship seemed like a planet. A planet all alone in a boundless sea. It looked enormous to me, obviously because there was nothing with which to compare it. What an incredible sight! You look at the stars and they are motionless. The sun appears as though it is pasted onto the velvet of the sky. Only the earth passes before the eyes. You get the impression that it is not yourself, but the earth that is flying. I sensed a slight movement of the ship when I pushed myself away from it. The ship moved in the opposite direction. I talked about this event and I still remember how I said it, word for word. All the same, the movement of the ship was sometimes appreciable.

"In space itself I was most fascinated with the expanse of it. You fly freely, at will, like a bird. You simply move your arms and legs. It is as though you get a feeling for your wings and fly. The space suit restricts your movements a little bit, but I bear no grudges against it. It was like a part of my own body. My 'territorial dominion' encompassed much area. I could move away from the ship, to the right, to the left for the entire length of the tether, fly forward and even ahead of the ship. The walls of

the spaceship did not confine me and I was not in a closed space. How wonderful it was to 'walk' up there as though at home.

"I experienced perhaps two of my most rewarding moments during the 10 minutes I spent in outer space. The first was when I left the ship, and the second was over the Volga, when I heard Levitan's voice on radio Moscow. The great Volga, upon which I looked from space, and the announcer's ceremonious report about our flight was an inspiring combination!"[1]

And here is what the "Voskhod-2" flight commander P. I. Belyayev says about the flight:

"Psychologists often talk about a psychological barrier. A man, they say, must overcome internal obstacles before he can get out of a spaceship and walk in space. One is afraid to walk from the edge of a precipice; one sees enormous altitude, a void, boundless space. One is afraid to be separated from his accustomed environment, his footing, in a word, the spaceship. Man experiences emotional reactions, a mental constraint, illusions of falling... So you see how many fears a cosmonaut must overcome in order to walk into open space. But we didn't conjecture about it. Only on earth, after returning from our flight, did we hear about the psychological barrier. We were so busy in space that we never thought about such things. Another important thing is that Aleksey Leonov, before going out into open space, did not experience any illusions or apprehension, much less fear.

"Why do I speak so confidently about Aleksey? Because I clearly saw the expression of his eyes and face on my television monitor. He seemed to be right next to me, as though I could reach out with my hand and touch him. I didn't have to guess what sensations he was experiencing. I know Aleksey well: he is an open man, and that which is on his mind and in his face is reflected as in a mirror. In his face and eyes I perceived boundless delight. At first, it is true, he was surprised by the brilliance of the sun. It shone so brightly that it resembled a welding arc. It even penetrated through the heavy light filter of his space helmet. But on earth it is difficult to see objects through it. They appear shadowy. The sun is bright in space! Nevertheless it does not interfere with vision and work under these unusual conditions. He looked around and his eyes sparkled. What a picture he saw! It thrilled the soul.

"By nature Aleksey is a very curious man. As they say, don't feed me bread, just let me look at something new and interesting. In the city he is always exploring unfamiliar streets in the hope of discovering something, both for himself and for us. When hunting in the woods he is distracted by some tree or bird and forgets about his shotgun. And now before his eyes unfolds a colorful map of the earth, with hazy mountains, blue-black sea, and in the black and infinite pit of space unblinking stars. The view from space is

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[1]"Ten Minutes in the Cosmic Void," KRASNAYA ZVEZDA (Red Star), 10 April 1965.

enough to satisfy anybody. But Aleksey's view was special, artistic, richer than mine or that of any other cosmonaut. Even on earth he had a special view toward space. His 'space pictures' were bright and variously colored. But then he 'saw' space through the stories of his comrades and in his own imagination. Now he saw it with his own eyes. The colors were 10 times brighter and more diversified. And not only colors. In space everything is unusual and striking. Even the first glance was striking. I heard Aleksey's excited voice: 'How bright it is out here, how great!..." In his enthusiasm he struck the hatch exit with his hand and I heard the sound. All sounds are transmitted distinctly in the spaceship. He tapped the skin of the spaceship and I heard that. If he brushed against something a little bit that was also audible. The sounds passed through the metal and into the ship.

"I have already explained that Aleksey was eager to go out into space and I had to restrain him. Convinced that his pulse and respiration were normal and that he himself was also normal, he said: 'Let me go out.' That was in the airlock, near the hatch itself. Now Aleksey viewed space from the hatch. I was a bit concerned: distracted by the beauty of space, he again would become impatient, push off sharply and become entangled. But my concern was unjustified, because he did everything just as he was taught.

"During training exercises Aleksey left the spaceship unhurriedly and calmly. We took the advice of Andriyan Nikolayev: 'The main thing is to be calm.' Aleksey made his exit from the spaceship according to the book: he first removed one hand from the hatch opening, and then a leg... He went out carefully about 20 centimeters. He smiled: everything was in order. But until then I practically held my breath. I was worried about my friend. His smile reassured me. Nevertheless I waited tensely: what next? He pushed off smoothly and waved his hands. I hear: 'Everything is alright, I feel fine.' His voice was as before -- excited and joyful. And his voice warmed me. Joyfully, and with a quavering voice, I transmitted to earth: 'Man has gone into space.' I repeated this message twice.

"It was not simply a message, but an event, I might say, of global importance. For the first time an inhabitant of the earth had embarked on 'independent' flight, walking freely in the cosmic ocean. The door to the Universe was open. We used to read about this in science fiction stories and tales. It was once a dream. Now it was a reality. I had waited for this moment. I was ready for it. Nevertheless my composure, my 'preparedness' vanished when Aleksey Leonov walked into open space. My friend, in fulfillment of his dream and aspiration and of the flight, was in space! In my presence, before my very eyes, he accomplished something that had never been done before. How could the people on earth be told about this unemotionally?

"I experienced a feeling of great pride in my country, our party and our scientists, designers, engineers and workers who had elevated us into space. Those are strong words, perhaps, but they are true. We did not speak them in space, but we speak them now, because without them we cannot

completely express our thoughts and feelings. In space we heard adjectives that were voiced by the entire planet: 'Sensational!' 'Staggering!' 'Tremendous!' We related them to our country, which courageously and systematically learning the secrets of space."[1]

A Soviet man accomplished what would seem to be the improbable. He abandoned the safety of his spaceship and went out into the mysterious world of space. Leonov took the first steps in space. He moved around freely and performed several experiments that were of tremendous practical importance for future investigation and exploration of space for the benefit of world science. Cosmonaut Leonov met space "face to face."

[1]"Ten Minutes in the Cosmic Void," KRASNAYA ZVEZDA, 10 April 1965.

EARTH RECEIVES HER HEROES

After A. A. Leonov returned to the spaceship from outer space the flight of "Voskhod-2" continued under P. I. Belyayev's control. The crew conducted a program of astronautical observations and measurements. At 0414 hours Moscow time on 19 March spaceship "Voskhod-2" appeared over the Soviet Union (the Far East), and one of the tracking stations immediately established radio communications with it in the UHF band. All systems of the spaceship were functioning normally and A. A. Leonov and P. I. Belyayev felt fine. The flight program of spaceship "Voskhod-2" was completed.

It was time for them to go to the landing area. After some brief meetings we go to the airport, where an An-10 is already prepared for takeoff. We take our seats in the cabin. The airplane takes off and quickly climbs to an altitude of 7,000 meters. Aboard the airplane are physicians, engineers, mechanics and other specialists, who are members of the reception party. The flight commander maintains radio communications with the command center. It is a short flight. The airplane begins to descend for landing at Kustanay airport. We are informed that some problems were discovered in the airplane's automation system. After a brief stop we again are airborne and take a heading toward Perm'. Concern for the fate of the crew of "Voskhod" grips us all. How will the landing of the spaceship and cosmonauts go?

After several hours our airplane lands near Perm'. We go to the command center of the recovery and reception group; it is already busily engaged in its work. On a special platform not far from the command center the antenna systems of electronic control, tracking and communications systems rotate continuously. Operators, who listen intently to the air waves, awaiting signals from "Voskhod," work around the clock in the operations room, in which are installed receiving-transmitting sets. Another group of operators attentively watches for the appearance of blips on radar scopes, analyzing them carefully. On a table in the operations group office lies a large map, filled with red lines. They are the final orbits, in which "Voskhod-2" will finish its flight. It is in the last, 17th orbit, at the end of which, after orientation of the spaceship, the retrorockets will be fired, after which it gradually will begin to lose altitude and velocity, re-entering the dense layers of the atmosphere.

Continuous radio communications are maintained with "Voskhod-2." The tension mounts. Flight commander P. I. Belyayev reports that the automatic guidance system of the ship did not function. Belyayev's voice is calm and smooth, despite the fact that he is, of course, concerned. He indeed understands that much depends on him right now. The ship cannot be landed by the automatic re-entry cycle. He himself must bring the ship down. This was the first time in history of manned space flights that manual control would be used.

"Almaz," Almaz -- received your report. We confirm that the automatic system of the spaceship did not function," replied Yu. A. Gagarin. "The State Commission has decided to use manual control in the 18th orbit."

"Roger, this is Almaz. Use manual control."

P. I. Belyayev started performing operations related to descent of the spaceship from orbit and landing. At 11 hours 19 minutes 00 seconds he turned on the manual guidance system of the spaceship. The ship was oriented on three axes: pitch, roll and heading. Then P. I. Belyayev fired the retrorocket system.

"Voskhod-2" started descent from orbit. The spaceship retained the same orientation as the one in which it was placed by P. I. Belyayev. A few minutes later, after the spaceship had left its orbit, the orbital and instrument compartments were separated at the prescribed altitude from the descent vehicle. The descent vehicle with the cosmonauts re-entered the dense layers of the atmosphere.

At 11 hours 56 minutes 08 seconds, at an altitude of 5,000 m, when the velocity of the descent vehicle was 220 m/s, the parachute landing system was deployed. Soft landing motors were fired just before touchdown.

At 12 hours 02 minutes 17 seconds of 19 March 1965 the descent vehicle and cosmonauts P. I. Belyayev and A. A. Leonov landed 180 km northwest of Perm' (59°34'03" north latitude, 55°28'0" east longitude).

The bright-orange and white striped parachutes hung on the tops of tall pines. The spaceship was squeezed on three sides among large pine trees and was sunk in deep snow. P. I. Belyayev and A. A. Leonov made an attempt to open the hatch of the cockpit and get out of it, but they failed. Some time later, after the recovery team arrived and the hatch was finally opened Belyayev and Leonov got out of the cockpit, removed their space suits and donned flight jackets and trousers, delivered to them by helicopter. Everybody rushed toward the cosmonauts: lumberjacks, hunters, physicians, camera men and we athletic commissars. Airplanes and helicopters flew overhead. The cosmonauts turned on a radio set and reported to the State Commission about their landing.

Some time passes and we meet the space heroes. They are in their flight jackets, unshaven, a little tired, laughing, and with their arms raised

they walk toward us. I embrace and firmly kiss first Aleksey Leonov and then Pavel Belyayev. From my heart I congratulated them on their successful flight and landing and their outstanding completion of a new, world-first experiment, a walk by man in outer space. I also congratulate them on their setting of absolute and world space records. The cosmonauts smile and thank me for my congratulations.

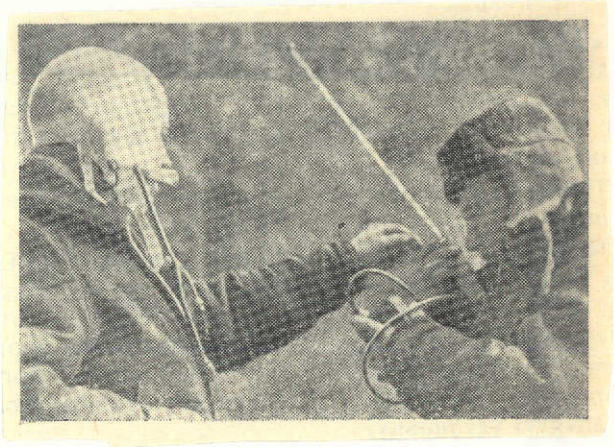

Figure 14. "Voskhod-2" flight commander P. I. Belyayev radios to command center about landing. On left is A. A. Leonov.

Figure 15. Homecoming after flight.

The space heroes arrive at Perm' airport. They come under the fire of movie cameras and photographers. Pioneers bring P. I. Belyayev and A. A. Leonov bouquets of flowers. People instantaneously surround them on all sides. Then a living human corridor is formed, through which walk P. I. Belyayev and A. A. Leonov, slowly and in the company of a large group of reporters and photographers. All applaud warmly and joyfully greet the heroic crew, which inscribed a new page in the history of man's exploration of the universe. People with smiling faces and greetings accompany P. I. Belyayev and A. A. Leonov to their car, which is surrounded by a ring of welcomers.

Finally they are able to get into it. The cosmonauts are driven slowly to the cottage, where they will be greeted by reporters and officials of Party and Soviet offices of Perm' oblast and city.

They are warmly greeted by the first secretary of the Party obkom on behalf of the citizens of the city and oblast. The cosmonauts are presented with gifts. Among them are a set of fitter's tools and a model of an electric saw. They receive many telegrams, addressed to their homes, expressing admiration for their great exploit and congratulations on their successful homecoming.

Then a brief news conference was held, at which the cosmonauts answered some questions. Answering questions, A. A. Leonov said: "When I stepped out of the spaceship into space I knew that I would see no one there, everything around me was bright and empty. I moved around any way I pleased."

Figure 16. On 21 March 1965, from the landing area, the cosmonauts report to the Government about the completion of the mission.

By way of closing the press conference P. I. Belyayev and A. A. Leonov thanked the Permians for their warm and sincere reception. Soon the cosmonauts and we were driven to an An-10, which would take us to the cosmodrome.

There in the airplane we had a meeting with P. I. Belyayev and A. A. Leonov and filled out all necessary forms, which would be submitted to Records Affidavit. We asked them questions about their flight, about their work in space, about all their impressions of the space trip and, of course, about A. A. Leonov's space walk. To my question "What is it like in space?" Aleksey Arkhipovich replied: "In general it is possible to live and work." We had many questions, and they gladly answered them. But now it was time for the cosmonauts to rest. We all left the cabin and they lay down to sleep.

The flight is almost over and we will soon be at the cosmodrome, whence the cosmonauts were launched into space on 18 March. As the plane descended we saw many people at the air field. Cosmonauts, scientists, designers, workers, communications specialists, journalists and members of the State Commission came to greet the space heroes. The airplane taxis to the tarmac and stops. As soon as P. I. Belyayev and A. A. Leonov appear at the open doors of the airplane all present there greet them with thundering cheers. "Voskhod-2" flight commander Pavel Belyayev reported to the chairman of the State Commission on the completion of the flight program. They embrace firmly. Then the chairman approaches A. A. Leonov, kisses him firmly and warmly congratulates him on accomplishing the world's first space walk. Then the space heroes are embraced by S. P. Korolev, M. V. Keldysh and other scientists, members of the State Commission, cosmonauts Yu. A. Gagarin, V. M. Komarov and friends.

The cosmonauts ride in an open car to Zvezdograd, where a warm reception awaits them.

Both sides of the streets on which P. I. Belyayev and A. A. Leonov will travel are lined by citizens of the city. Banners can be seen everywhere. As soon as the car carrying the cosmonauts appeared on one of the streets everybody cheered "Hurrah!" and greeted the crew of "Voskhod-2" with thunderous applause. Literally all theiinhabitants of the city came out to greet the space explorers. P. I. Belyayev and A. A. Leonov stand in acknowledgement of their reception. For the entire trip from the airport to the hotel, where the cosmonauts would rest, they were greated sincerely and warmly by the entire population of Baykonur cosmodrome. At the hotel the cosmonauts had an opportunity to talk by telephone with their families. After a brief rest the cosmonauts met briefly with the chairman and members of the State Commission, S. P. Korolev, and M. V. Keldysh. The cosmonauts shared their impressions of their flight.

Words cannot express what I felt when I heard the brief stories of flight commander P. I. Belyayev and aviator-cosmonaut A. A. Leonov, who was the first to step out of a spaceship into open space. The cosmonauts explained that the flight went according to schedule and that the space walk was successful. Landing was accomplished by manual control. Mother earth received her space heroes warmly and cordially.

Because of the fact that a meeting with the State Commission was scheduled for the next day, at which the cosmonauts would report in greater detail about their flight aboard spaceship "Voskhod-2" and the completion of their program, this meeting continued only briefly.

The cosmonauts were then invited to a press conference, which was held here in the sports arena.

Reporters from the central newspapers, TASS and All-Union radio and television, present at the cosmodrome, first congratulated P. I. Belyayev and A. A. Leonov on their great victory. Then the space heroes answered

questions asked by the reporters. I offer in condensed form the content of this conference as recorded by special correspondent of TASS, A. P. Romanov.

"P. Belyayev: You ask how we felt? We felt fine.

"A. Leonov: Our condition is excellent! You certainly can see that for yourself.

"P. Belyayev: The scientific program, calling for Aleksey Leonov to leave the spaceship and go into space, was completely fulfilled. All systems of the ship operated perfectly. I will explain to you how it all happened.

"The time came, we were above the Soviet Union, and I put my arm around Alesh's shoulder and said: 'It is time.' The airlock system was placed in readiness, as we rehearsed many times back on earth. We opened the hatch and Aleksey vanished in it. Don't think that I was so calm. I was very concerned. Space is space. We already knew quite a bit about it, but man would be going into unexplored space for the very first time. I hear my heart pounding. But I attentively watch the progress of my comrade as he passes through the airlock. In a few minutes Aleksey was outside the ship. We talked to each other all the while. I determined his distance from the ship by instruments. We worked patiently in order to complete the scientific mission as accurately as possible. It is not my nature to hurry unnecessarily. We did everything calmly, deliberately and confidently.

"A. Leonov: My comrades who had been in space told me much about it, I read scientific works and attended lectures. Nevertheless that which I saw in space outside of the atmosphere surprised me. The earth below appeared flat and its curvature could be seen only on the horizon. The distance of hundreds of kilometers at which the ship was flying was not enough so that the earth could be seen as a sphere like the moon. The sky beyond us was jet black. The stars were bright, but they did not flicker or twinkle. And the sun was unearthly, without a corona, as though it were embedded in black velvet. It was a strange sight. Did it frighten me? No. But when you are out there alone... It is good to have a friend around.

"The flight commander constantly watched my activities in space. His smooth, confident voice 'Take your time, Alesha, do it as they taught you,' reassured me and I lost myself in the strangeness of the space surrounding me. During those minutes I maintained radio communications not only with Belyayev, but also with the earth. This also meant a lot to me. Outside of "Voskhod-2" I listened to Moscow radio. Announcer Levitan read the TASS report about our flight. It was a little strange to hear that announcement at such a tremendous altitude, far from Moscow...

"The appointed time arrived and Pavel Belyayev instructed me to come in. That turned out to be a more difficult task. When I got out of the hatch it was a simple, even easy process. The ship rocked and seemed to lurch forward from the push produced by my movement. But we did not become separated from each other. We were firmly connected by the tether, a

unique rope. In order to return to the cockpit I had to 'hold myself up by my ears,' as they say and use my head.

"P. Belyayev: Aleksey, explain to them in a little greater detail what you saw while in space.

"A. Leonov: Of course. Our universe is infinite in all four dimensions. The earth is far below, but everything on it can be seen very clearly. We saw the Black Sea and the Sea of Azov. Over the Caucasus we noticed a cloudy haze. I looked for the "Sochi" sanatorium, where we have relaxed often, but I did not find it. That was a pity. From space the earth is illuminated by the sun. It was easy to distinguish the Volga, Yenisey and Irtysh and places with which I am familiar. I agree with the other cosmonauts: our earth is beautiful, very beautiful. I looked upon her and fell in love with her. And when you were working, you ask? Everything I did, beginning with the opening of the hatch, was work. I went out into space and moved first one hand and then the other, and then I moved my legs. All was normal. Everything was fine. My vestibular system was functioning properly. Then I flapped my arms like wings. It was a very pleasant sensation. You must remember that everything I am telling you about was included in the flight program.

"I used the 12 minutes that I spent outside of the spaceship to the fullest extent. The movement of my arms is an element of labor processes, without which space cannot be conquered. The assembly of an orbital station, the carrying of equipment outside a spaceship, all such tasks will have to be performed if we are to master near-earth space and make it useful to earth. I hasten to add that Pavel Ivanovich had to do a great deal of work. In addition to the responsibilities that are usually performed by the commander of a spaceship, he participated actively in the space walk experiment.

"Some people like to compare swimming in space with swimming in water. There you sense support and movement. In space there are no such sensations. You simply fly around the ship. If you risk leaving the spaceship, then, of course, you will fly forever in some unknown orbit in dark mysterious space. It is reassuring to know that you are firmly attached to the spaceship, to a little part of earth.

"P. Belyayev: Our ship was very sensitive to Aleksey Leonov's movements. It reacted to each step he took in space. Sometimes I got the impression of a seesaw, at the ends of which stand two men, alternately lifting each other up. I could hear Aleksey hitting the wall of the spaceship with his boots and tapping the surface of the spaceship with his hands.

"A. Leonov: You know, "Voskhod-2" looked so great in space! I looked at it from a distance of 5 meters and admired it. The windows looked like large eyes and the antennas looked like thin feelers. Don't think for a minute that everything I did near the ship was effortless, that everything was easy, as on earth. No, I became quite tired. Don't forget that I was wearing a space suit. It provided me with complete protection in space,

but nevertheless we have still not become accustomed to working in it. The gloves which I wore on my hands, of course, are not as simple and convenient as those we wear on earth. I spent 20 minutes in difficult conditions outside the cockpit. It would take about an hour and a half for me to write down everything that I saw and the work I performed. I entered everything in our ship's log so that we would not forget.

"And so it is nice in space, but it is still better inside the ship. The ship was like a small road and it was our home, and most importantly, my friend Pavel Belyayev was inside. When I returned from space into our home, Belyayev joyfully exclaimed: 'Good boy!' We closed the hatch and continued our flight. During the experiment, of course, we were not standing in place, but traveling at a velocity of approximately 28,000 km/hr.

"The next day I had a chance to say 'Good boy' to Pavel Belyayev. It was in the 18th orbit on 19 March, when he easily landed "Voskhod-2" on our homeland by manual control.

"P. Belyayev: Soviet space technology has created a wonderful soft landing system. It operated just as we rehearsed it during training. I switched to manual control at exactly the prescribed time. All the calculations that we did before the flight were correct. All systems functioned perfectly. We were the first cosmonauts to use manual control to land a spaceship returning from near-earth space. It did not fail us.

"A. Leonov: Landing by manual control, of course, places responsibilities on the flight commander. It is one thing when the retrorockets are fired by command from earth, but it is another thing when you have to do it yourself inside the spaceship.

"P. Belyayev: I would like to add a few words. No artist ever painted a picture of limitless space such as we saw with our own eyes. There is not a writer alive who could give a creative description of endless space. Even the most daring idea of the science fiction writer cannot convey the enormity of space. No, you must see it with your own eyes in order to recreate even a fragment of the universe.

"We are used to seeing stars as blue, but we were fortunate to see stars of pure gold. They appeared as though scattered against a black background by a careless hand.

"A. Leonov: And they actually seemed bright, colored in fact, similar to pure gold. I even sketched them in my log. Incidentally, it is not too difficult to write and sketch in weightlessness. You simply press the pencil a little firmer on the paper and practice a little.

"P. Belyayev: Just the same, it was an astounding sight -- the universe with its myriad of stars and the sun, breaking the darkness. We attentively observed through the windows everything that we could see. Suddenly our attention was attracted by an object bathed in sun rays. We screamed with

surprise and joy. Not far from our ship, about a kilometer, flew an artificial earth satellite. This encounter inspired us greatly. The thought occurred to me that the time will come when meetings in space with other emissaries of earth will be commonplace. We will learn to meet each other in the paths of space and even move from ship to ship. Our space walk experiment is a step to the solution of this important space navigation problem.

"A. Leonov: The earth has an impressive wealth of color. As the spaceship emerged from the dark side into the light we saw one array of colors, but when we flew from the light side into the dark we saw another array of colors, in which violet, blue and dark blue hues predominated.

"P. Belyayev: Let me tell you about the last stage of the flight, the landing. The retrorockets fired and the ship began to descend. It re-entered the dense layers of the atmosphere. We were glad to see earthly sun rays dancing in the window. Below our native country was covered with snow. And our spaceship landed without our being aware of it. Aleksey Leonov and I were in the taiga...

"A short time later we were received and embraced by the welcoming party. They congratulated us on our successful completion of the flight. They were not, it is true, the first congratulations. When we got out of the cabin we congratulated each other with great satisfaction on our return to earth" [9].

After the press conference P. I. Belyayev and A. A. Leonov were examined by physicians, who very carefully and attentively checked the health of the cosmonauts after their space journey. The physicians reported to us that their health was fine and there were no deviations from normal. Everything was in order.

The next day, 22 March, the cosmonauts attended a meeting with the State Commission, where each of them would report on the completion of the flight program aboard "Voskhod-2."

I wrote Belyayev's and Leonov's reports in my note pad. They agree basically with their accounts to the press, which we have just read.

Thus ended the space journey of cosmonauts P. Belyayev and A. Leonov.

They were now ready to be received in Moscow.

A special I1-18 airplane was dispatched to the cosmodrome for the cosmonauts. P. I. Belyayev, A. A. Leonov, N. P. Kamanin, reporters and we athletic commissars boarded it. After takeoff the plane made a large sweeping turn. Below we saw the launch pad from which the spaceship "Voskhod-2" was launched. The I1-18 gaines altitude. The cabin of the airplane is filled with laughter and jokes. P. I. Belyayev and A. A. Leonov read the latest issues of newspapers, brought by the crew of the airplane.

Shortly Belyayev and Leonov enter the cockpit and, alternately sitting in the right hand seat, next to the flight commander, fly the airplane. This is by then a tradition. The flight altitude is 7,000 meters. A brief press conference is held, at which Belyayev and Leonov answer numerous questions. The reporters obtained autographs of the cosmonauts. The airplane receives more and more radio messages in honor of Belyayev and Leonov. The cosmonauts write greeting telegrams to their fellow earthlings - P. I. Belyayev to Vologdites and A. A. Leonov to Kemerovians.

Soon we arrive at Moscow. Breaking through the cloud cover, the airplane begins its descent. On the approach to Vnukovo airport the Il-18 is joined by an honor escort of fighter planes, which accompany the airplane.

Many people line Leninskiy prospekt and streets around the Kremlin. Red flags and banners can be seen everywhere.

P. I. Belyayev and A. A. Leonov don their full-dress aviator uniforms. The cosmonauts seem excited. The Il-18 taxis up to "Vnukovo-2" terminal. Cosmonauts P. I. Belyayev and A. A. Leonov step down the ladder from the airplane and walk down a carpeted walkway to a rostrum. They present a brief report on the completion of their mission. This is followed by a moving meeting with relatives and friends.

On the same day a meeting was held in Red Square in honor of the heroes.

A press conference of Soviet and foreign journalists was held on 26 March 1965 at Moscow State University imeni M. V. Lomonosov in Leninskiye Gory.

When Soviet space explorers P. I. Belyayev and A. A. Leonov appeared in the hall everyone stood. Soviet and foreign reporters, scientists, members of the diplomatic corps applauded the great feat of the Soviet people, the courage of the Cosmonauts, the ingenuity of the scientists and designers and the selfless labor of all the people who helped to prepare the historic flight of spaceship "Voskhod-2."

The president of the USSR Academy of Sciences M. V. Keldysh, aviator-cosmonauts P. I. Belyayev and A. A. Leonov spoke at the press conference. A "spontaneous program" press conference took place after the speeches. The entire table of the presidium was inundated by notes.

In the notes of special correspondents of IZVESTIYA B. Koltovoy and B. Konovalov we read about this conference:

"How long can a spaceship of the type 'Voskhod-2' stay in orbit around the earth with two crew members?"

"More than a month." (A roar of admiration reverberates through the hall).

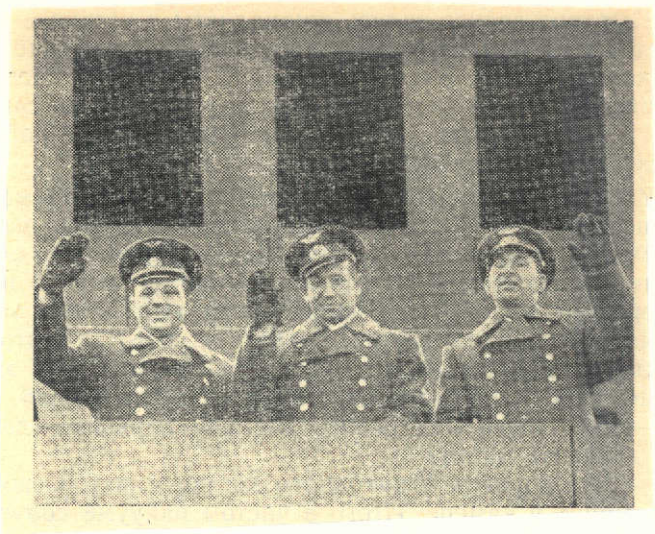

Figure 17. Cosmonauts Yu. A. Gagarin, A. A. Leonov and P. I. Belyayev on platform of Mausoleum.

"Do spaceships of the type 'Voskhod-2' have the capacity to maneuver and change orbit, like the spaceship 'Polet'"?

"Yes, but in this case the flight program did not call for maneuvering."

"It has been said in past years that spaceships could be used again after flights. Is this true of 'Voskhod-2'"?

"Yes, to the fullest extent."

"Did the spaceship collide with trees during landing and how much damage did the spaceship incur as a result of landing?"

"The landing was very soft and the spaceship suffered no damage."

"Could the spaceship be guided directly before landing and could possible obstacles be avoided?"

"There is no need for that for a soft landing of 'Voskhod-2.'"

The reporters listened inquisitively to the competent and unhurried answers of the celebrated "Voskhod-2" flight commander, Col P. I. Belyayev, to questions primarily concerning the qualities of the great machine, created through the genius of the designers and by the golden hands of the workers of our industry.

The commander was followed to the podium by Aleksey Leonov, the man who took the first steps in open space. He already had said much in his circumspective speech. But the journalists' interest in the smallest details of the unusual experiment remained unquenched, and understandably so. Mankind

wants to learn as much as it can about the exploit, which yesterday was still the sole property of the heroes of science fiction stories.

"How long did you stay outside of the ship, 10 or 20 minutes?"

"I spent 10 minutes outside of the ship and another 10 minutes inside the airlock. I spent a total of 20 minutes in pure vacuum."

"Before the launch of 'Voskhod-2' you jokingly said: 'I will be a high-altitude fitter.' Did your mission include assembly operations? Builders want to know if construction and assembly specialties will be required in space."

"I have already said that I did some assembly and dismantling operations. As regards builders, I think they may start getting themselves ready."

"When you were outside the ship did you screw anything together or unscrew anything, and if so did you use any special tool?"

"I did not use a special tool, although I could have. I removed the camera from its mount, and before that I removed the lens cover and sent it into a new orbit. You will see the film today and you can make your own assessment."

"Did you breathe through the tether or did part of your oxygen come from the cylinder on your back?"

"The entire space walk was done with a self-contained backpack system."

"What means of communications did you have in your space suit?"

"My communications with the flight commander was by telephone. It was built into the tether. In addition, the flight commander has already said that he heard perfectly all the 'racket' I made in space through the walls of the spaceship."

"What would have happened had you been unconscious after leaving the spaceship? Are there automatic devices that would have brought you back into 'Voskhod-2' in such an event?"

"I believe that the flight commander could have rescued me."

"You are not only the first man ever to walk in space, but you are also the first cosmonaut artist. Can you tell us what is the color of space? Would you find in space a combination of colors that can be used on earth?"

"My drawings were first published in the press in 1961. They were spacescapes. I based them on the descriptions of my comrades who had already traveled in space. Now I have seen it myself and have decided that they were right."

The progress that has been made by our cosmonautics is truly astounding. Less than 4 years ago man made his first flight into space, and now multi-place spaceships are being launched into orbit and a cosmonaut has climbed from an airlock into a star-filled ocean. This is today. What will the future bring? President of the USSR Academy of Sciences Academician M. V. Keldysh answers the reporters' questions concerning the future of cosmonautics.

"Will cosmonauts be able to transfer in future flights from one spaceship to another?"

"I think so. Undoubtedly the latest experiment is a big step in this direction."

"What space flight problems must still be solved before large constructions can be assembled in orbit?"

"There are many problems, but they most important one is rendezvous of different spaceships."

"What stages and problems of space exploration are considered to be most important in the Soviet Union up until 1970?"

"It is hard to list them all. We feel that the most important ones are the development of manned flights, construction of interplanetary stations, exploration of other planets, investigation of the physical and other properties of space..."

Aleksey Leonov said in his speech that the "raisins" of his flight aboard spaceship "Voskhod-2" were the 20 minutes which he spent in the airlock and in "open space." The "raisin" of the press conference was undoubtedly the showing of the movie film taken in space. The hall froze in anticipation. The unprecedented feat would now be shown on the screen.

...The speakers played Belyayev's voice, shrieking somewhat with excitement:

"Zarya! This is Almaz! Man has entered space."

There he is! Aleksey Leonov opens the hatch cover and stands, spellbound by the view that unfolds before him.

"I see the sky, the earth!" the joyous voice of the trailblazer explodes from the screen.

Leonov slowly unwinds the tether and waves his arms as he pushes away from the ship. Someone in the half dark hall utters a frightened sigh. The first man will "cook" in space! For a while his movements are slow and cautious, but now he begins to frolic like a dolphin. The sun bursts onto the screen. How blinding it is becomes evident. The frames immediately darken as soon as the space suit eclipses the great star. It is as though man is playing with the sun, first revealing and then concealing its rays.

"It is possible to work in space," is heard Leonov's voice.

Smiles light up the hall. Somehow it seems difficult to reconcile this frolicing with our notion of work. But it was only yesterday that the very idea of man walking in space seemed incredible. It was clearer to the cosmonauts. If Leonov says that it is possible to work, then work will be done!"

WORLD RECORD ACHIEVEMENT

The Soviet Union is correctly considered to be the land of cosmonautics. She gave the world the father of space travel, the eminent scientist, theoretician and rocket designer K. E. Tsiolkovskiy. Our country launched the world's first artificial satellite, landed an automatic station on the lunar surface and put man in space for the first time. A Soviet man was the first to step into outer space. Yuriy Alekseyevich Gagarin blazedthe first path in space. That accomplishment was followed by a day-long flight, the first space flight by a woman, the first group space flight and flight of a multiplace spaceship. By the end of 1964 nine Soviet aviator-cosmonauts had logged 405 hours 17 minutes 19 seconds in space. That is more than 17 days. During that time they flew a total of 11,331,524 kilometers and completed 275 orbits around the earth. The year 1965 added to the score card of the world records of Soviet cosmonauts yet another event, the flight of the spaceship "Voskhod-2," from which man walked into open space for the first time in history. But we are not, of course, concerned simply with records. We do not view our space program as an end, as some race, and the spirit of reckless gamblers in this great and serious matter is profoundly alien to us.

We feel that space exploration is a component part of the vast creative work that is being done by the Soviet people in all fields of economics, science and culture. Space flight is work first and foremost, and cosmonauts are workers, just like those who work in plants and factories, in the fields and in science laboratories. We, therefore, proudly call our cosmonauts space workers.

It is well known that the aviator-cosmonauts of our country, as well as our designers, scientists, engineers and workers, have been praised not only by the Soviet people for their tremendous contribution to space exploration, but also by many international organizations, including the International Aviation Federation (FAI), which deals with scientific-technical and record achievements in aviation and cosmonauts all over the world, compares them and thereby promotes the development of conceptual design and aerospace technology. FAI develops and confirms policies on the recording of record and scientific-technical achievements in the aerospace field. This prestigious international organization combines national aviation clubs,

aviation federations and associations of more than 65 countries around the world. It develops and constantly updates aerospace sports codes concerning the conditions, order of achievement, recording and discussion of world records.

The history of FAI, which will mark its 70th anniversary in 1975, is closely associated with the development of the aerospace industry. Up until 1960 FAI was engaged in the registration of records only in the field of aviation. The rapid development of science and technology, especially of rockets, confronted the International Aviation Federation with the problem of the development of new rules and policies that would make it possible to record outstanding world accomplishments during manned flights of rockets in space.

The regular 53d general conference of FAI was held in Barcelona in October of 1960. It was at that conference that policies and rules on the registration of space records were first adopted. It was specified in these documents that FAI will recognize only records that are established as a result of space flights beyond an altitude of 100 km. This means that flights at altitudes up to 100 km are left for futurerrecords in aviation. In order that records, set in space by a spaceship be officially recognized and registered a Record Flight Affidavit must be submitted after the flight to FAI for confirmation.

This affidavit must include data on the launch, flight and landing, and also general information about the astronaut, type, make and power (thrust) of the booster rocket, the results of processing of all data at the coordination computer center, a description of the construction of the spaceship or satellite, telemetry information, a brief description of the measuring instruments and flight program, the astronaut's personal report on the flight aboard the spaceship or satellite and much other information, along with diagrams, calculations, tables and graphs that characterize all parameters and data of the space flight. In addition the affidavit must state the nationality of the flight commander of the spaceship and of the crew members, the number and date of the flight commander's sports certificate and the identification emblems of the spaceship.

Thus, for the first time in its history FAI adopted a resolution on the registration of records in space. The conference delegates approved it and assessed it as a step, reflecting the federation's effort to keep in step with the rapid development of science and technology.

The special Astronautical Commission, consisting of representatives from England, Belgium, Italy, Poland, USSR, United States, Czechoslovakia and other countries, was established in March 1962 for the purpose of examining and registering data on space records. The Commission of Sports-Technical Problems of Cosmonautics, dealing with problems of the development of new policies and conditions on the determination and registration of record achievements by manned and automatic space vehicles, was established the same year in the Soviet Union under the USSR Federation of Aviation Sports.

In this connection we sports commissars had to fulfill our obligations, as specified in the Sports Code, during the flight of the spaceship "Voskhod-2."

Immediately after the landing of "Voskhod-2" we began to prepare materials on this notable flight and on new world records set by the cosmonauts.

During that 24-hour orbital flight P. I. Belyayev and A. A. Leonov, aboard spaceship "Voskhod-2," on the 18-19 March 1965 set an absolute world altitude record of 497.7 km. In addition the absolute world record time spent in open space outside of the spaceship, 12 minutes 9 seconds, was set by aviator-cosmonaut of the USSR A. A. Leonov.

Data on these records, which we present herein, and other data that accurately reflect all parameters of the space flight after their processing at the "Moscow-Cosmos" coordination computer center, were included in the so-called "Records Affidavit."

I have before me a large leather-bound file folder. Embossed in gold on the front cover are the words: "Affidavit Concerning Records of World's First Flight Involving Space Walk aboard Satellite-Spaceship "Voskhod-2" of 18-19 March 1965 by Crew Consisting of Soviet Citizens: Flight Commander Aviator-Cosmonaut Belyayev, Pavel Ivanovich and Copilot Aviator-Cosmonaut Leonov, Aleksey Arkhipovich."

I open the folder and fill out the "itinerary" on the pages of the "Affidavit"...

USSR FEDERATION OF AVIATION SPORTS

(Member of International Aviation Federation)

GENERAL INFORMATION FORM

1. Records: world record time spent by cosmonaut outside of spaceship in space suit with self-contained life support system; world record maximum space flight altitude; world record maximum space flight altitude for multiplace spaceships (from 2 to 4 crew members), in category one orbital flights.

2. Flight commander: BELYAYEV, Pavel Ivanovich, sports certificate No. 10, date of issuance 15 January 1965.

3. Copilot: LEONOV, Aleksey Arkhipovich, sports certificate No. 11, date of issuance 15 January 1965.

4. Citizenship: both crew members are citizens of the USSR.

5. Type of vehicle: rocket.

6. Make of vehicle: "Voskhod-2."

7. Brief description of vehicle: vehicle consists of multistage booster rocket and satellite-spaceship. Satellite-spaceship has: cockpit with

hatches and windows with accommodations for a crew consisting of two members and equipment; instrument compartment with guidance and communication equipment; space walk life support system; retrorocket system; backup retrorocket; landing system.

8. Identification emblems: "SSSR-Voskhod-2."

9. Number and date of issuance of log book of vehicle: log book No. 4, 6 February 1965.

10. Motors installed on vehicle:

a) type: liquid-fueled rocket motors;
b) make: "Voskhod";
c) power or thrust: total maximum thrust of motors of all stages 650,000 kg;
d) number of types of motors: 7.

Sports Commissars of USSR
Federation of Aviation Sports — Anokhin, S. N.
Kuvshinov, L. M.

USSR FEDERATION OF AVIATION SPORTS

(Member of International Aviation Federation)

STATEMENT
on launch of rocket with satellite-spaceship
"Voskhod-2"

18 March 1965. We, the undersigned sports commissars of the USSR Federation of Aviation Sports ANOKHIN, Sergey Nikolayevich, KUVSHINOV, Leonid Mikhaylovich and BORISENKO, Ivan Grigor'yevich, certify the launch of the rocket bearing the satellite-spaceship "Voskhod-2" with the identification emblems "SSSR-Voskhod-2," under the control of aviator-cosmonauts BELYAYEV, Pavel Ivanovich and LEONOV, Aleksey Arkhipovich, at 0700:00 hours Greenwich Mean Time from Baykonur cosmodrome.

Liftoff of the rocket took place at 0700:00 hours Greenwich Mean Time.

Liftoff time was recorded with stopwatch No. 1509503, the precision of which is indicated in the appendix.

Geographic coordinates of launch site:

47°22'00" north latitude
65°29'00" east longitude.

Appendix. Copy of certificate No. 3477/27 of state check of stopwatch No. 1509503.

Sports Commissars of USSR
Federation of Aviation Sports — Anokhin, S. N.
Kuvshinov, L. M.
Borisenko, I. G.

USSR FEDERATION OF AVIATION SPORTS

(Member of International Aviation Federation)

STATEMENT

of landing of satellite-spaceship "Voskhod-2" with aviator cosmonauts BELYAYEV, Pavel Ivanovich and LEONOV, Aleksey Arkhipovich

19 March 1965. We, the undersigned sports commissars of the USSR Federation of Aviation Sports, ANOKHIN, Sergey Nikolayevich and BORISENKO, Ivan Grigor'yevich, certify that on 19 March 1965, at 0902:17 hours Greenwich Mean Time, the satellite-spaceship, bearing the identification emblem: "SSSR-Voskhod-2" and crew consisting of BELYAYEV, P. I. and LEONOV, A. A., landed 180 kilometers north-northwest of the city of Perm'.

The time was recorded with stopwatch No. 1509503.

The geographic coordinates of the landing site of the satellite-spaceship "Voskhod-2" are:

59°34'03" north latitude
55°28'00" east longitude.

Sports Commissars of USSR Federation of Aviation Sports — Anokhin, S. N.; Borisenko, I. G.

USSR FEDERATION OF AVIATION SPORTS

(Member of International Aviation Federation)

STATEMENT

of determination of flight time of satellite-spaceship "Voskhod-2" with aviator-cosmonauts BELYAYEV, Pavel Ivanovich and LEONOV, Aleksey Arkhipovich of 18-19 March 1965

We, the undersigned sports commissars of the USSR Federation of Aviation Sports, ANOKHIN, Sergey Nikolayevich and BORISENKO, Ivan Grigor'yevich, certify the following:

on the basis of the statements of launch and landing and on the basis of examination of the results of processing of orbital tracking data of satellite-spaceship "Voskhod-2," flown by aviator-cosmonauts BELYAYEV, P. I. and LEONOV, A. A. on 18-19 March 1965, carried out the coordination computer center, it was established that the total flight time, from the launch of the rocket and satellite-spaceship "Voskhod-2" to the landing of satellite-spaceship "Voskhod-2," is 26 hours 02 minutes 17 seconds.

Sports Commissars of USSR Federation of Aviation Sports — Anokhin, S. N.; Borisenko, I. G.

USSR FEDERATION OF AVIATION SPORTS

(Member of International Aviation Federation)

STATEMENT

of the time spent by aviator-cosmonaut LEONOV, Aleksey Arkhipovich, outside satellite-spaceship "Voskhod-2" in space suit with self-contained life support system on 18 March 1965

We, the undersigned sports commissars of the USSR Federation of Aviation Sports, ANOKHIN, Sergey Nikolayevich and KUVSHINOV, Leonid Mikhaylovich, and engineer BALAKLEYTSEV, Vladimir Vasil'yevich, certify the following:

on the basis of examination of the results of processing of telemetry data and examination of all television materials and motion picture films, recording the entire process of the cosmonaut's space walk outside the spaceship in open space and his return into the ship, it was established that aviator-cosmonaut LEONOV, A. A. was outside the cockpit of the spaceship in conditions of outer space for 23 minutes 41 seconds. The time spent by the cosmonaut outside of the spaceship (from the time the cosmonaut emerged from the airlock to the time he disappeared in it) was 12 minutes 09 seconds.

Appendix. Time schedule of space walk by cosmonaut in open space and return to airlock.

Sports Commissars of USSR Federation of Aviation Sports — Anokhin, S. N.
Kuvshinov, L. M.

Engineer — Balakleytsev, V. V.

USSR FEDERATION OF AVIATION SPORTS

(Member of International Aviation Federation)

Time schedule of cosmonaut's space walk and return to airlock (Greenwich Mean Time)

1. At 0828:13 hours the airlock of the spaceship was completely unsealed.

2. At 0832:54 hours the hatch of the airlock of the spaceship was completely opened.

3. At 0834:51 hours the cosmonaut emerged from the airlock of the spaceship into outer space.

4. At 0847:00 hours the cosmonaut re-entered the airlock of the spaceship.

5. At 0848:40 hours the airlock hatch of the spaceship was closed.

6. At 0851:54 hours pressurization of the airlock of the spaceship began.

Engineer Balakleytsev, V. V.

C2

USSR FEDERATION OF AVIATION SPORTS

(Member of International Aviation Federation)

STATEMENT

of determination of maximum flight altitude of satellite-spaceship "Voskhod-2" with aviator-cosmonauts BELYAYEV, Pavel Ivanovich and LEONOV, Aleksey Arkhipovich, on 18-19 March 1965

We, the undersigned sports commissars of the USSR Federation of Aviation Sports ANOKHIN, Sergey Nikolayevich and KUVSHINOV, Leonid Mikhaylovich, and chief of the laboratory of the coordination computer center SEMENOVA, Klavdiay Zakharovna, certifyttthe following:

on the basis of examination of the results of processing of orbital tracking data during the flight of the satellite-spaceship "Voskhod-2" on 18-19 March 1965, carried out at the coordination computer center, it was established that the maximum flight altitude of satellite-spaceship "Voskhod-2" with aviator-cosmonauts BELYAYEV, P. I. and LEONOV, A. A. on board was 497.7 km.

Sports Commissars of USSR
Federation of Aviation Sports
Anokhin, S. N.
Kuvshinov, L. M.

Chief of Laboratory of Coordination Computer Center
Semenova, K. Z.

USSR FEDERATION OF AVIATION SPORTS

(Member of International Aviation Federation)

RE-ENTRY TIME SCHEDULE
(Greenwich Mean Time)

1. At 0819:00 hours the flight commander, at the control panel, actuated the manual guidance system of the satellite-spaceship.

2. At 0836:27 hours the flight commander at the control panel actuated the retrorocket system.

3. At 0856:08 hours the landing system of the satellite-spaceship was actuated by the automatic re-entry system, followed by the actuation of the soft landing system.

4. At 0902:17 hours touchdown of the satellite-spaceship occurred.

Engineer Viktorov, D. B.

Such are the basic statements of the "Affidavit." I shall describe other materials of this document briefly below.

In the section "Results of Processing of Orbital Tracking Data of the Flight of Satellite-Spaceship 'Voskhod-2' on 18-19 March 1965 and of Determination of Flight Altitude" it is stated that the orbital tracking data were processed by electronic computers at the coordination computer center. It was established that the maximum altitude above the earth's surface in the first orbit was 497.7 km and the velocity of the spaceship at that time was 7.31 km/s. Correspondingly the minimum flight altitude was 173.5 km, at which time the velocity of the satellite-spaceship was 7.70 km/s. "Voskhod-2" flew at a velocity of 7.60 km/s just before cosmonaut P. I. Belyayev fired the retrorocket system by manual control.

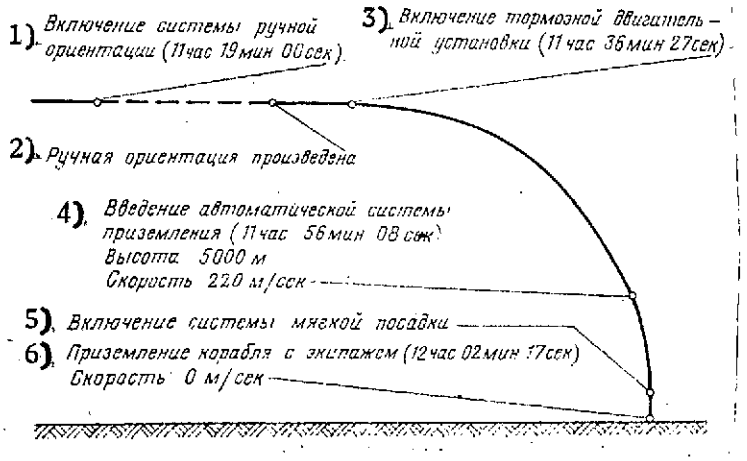

Figure 18. Diagram of re-entry and landing of "Voskhod-2." Moscow time indicated.

KEY: 1. Manual guidance system actuated (1119:00 hours)
2. Manual guidance performed
3. Retrorocket system fired (1136:27 hours)
4. Automatic landing system actuated (1156:08 hours) Altitude 5,000 m, velocity 220 m/s
5. Soft landing system actuated
6. Spaceship and crew touch down (1202:17 hours) Velocity 0 m/s

The orbital parameters of "Voskhod-2" in the 1st, 9th and 18th orbits are presented in the table below:

Parameters	3/18/65 1st orbit	3/18/65 9th orbit	3/19/65 18th orbit
Period (minutes)	90.944	90.928	90.910
Apogee (km)	497.7	496.2	494.6
Perigee (km)	173.5	173.3	173.1

The flight distance was determined as the sum of the distances of three segments of the flight:

$$L = L_{sh} + L_{orb} + L_{re},$$

where L is the total flight distance;

L_{sh} is flight distance from liftoff to the point of shutdown of the last stage engine of the booster rocket;

L_{orb} is flight distance from the point of shutdown of the last stage engine of the booster rocket to the point of firing of the retrorocket system;

L_{re} is flight distance from the point of firing of the retrorocket system to the point of touchdown of the satellite-spaceship.

Thus it was established that the maximum flight distance of "Voskhod-2" from liftoff to touchdown was 717,262.01 km. Measurements were taken at tracking stations, located along the flight path of the satellite in the Soviet Union. The network of tracking stations, equipped with electronic gear, operating by the satellite transponder principle, provided the required measurement accuracy and simultaneous precision time correlation of measurements at all tracking stations.

Another interesting section is the one containing "Description of the Construction of Satellite-Spaceship 'Voskhod-2' and Its Special Equipment." Let us read:

"The satellite-spaceship 'Voskhod-2' is a manned two-place rocket-propelled vehicle, developed as a modification of the 'Voskhod' satellite for the purpose of enabling a cosmonaut to leave the spaceship and go into space...

"The copilot leaves and returns to the ship through an airlock...

"The spaceship consists of the following:

hermetically sealed cockpit, which accommodates the crew, life support systems, food and water supplies, instruments for monitoring and controlling the systems of the ship, part of the electronic instrumentation, television cameras, television monitor, movie camera, instruments for medical and scientific research, re-entry and landing direction finding equipment;

instrument compartment, which houses the electronic instrumentation of the spaceship, liquid propellant of the retrorocket system, guidance system, heat control system and power sources.

"The ship is equipped with a backup solid propellant retrorocket, which duplicates the main retrorocket system, and an airlock to enable a cosmonaut to leave the spaceship, go into space and return to the ship...

"The airlock is installed on the cockpit of the spaceship and is connected to the cockpit by a hatch with a sealed cover.

"The hatch cover opens into the sealed cockpit and is opened and closed automatically by a special electric drive. The drive is controlled from the control panel. Manual control of the opening and closing of the hatch cover is also provided.

"To enable a cosmonaut to leave the airlock and go into space there is a hatch at the top of the airlock, equipped with a sealed cover, opened by means of an electric drive. The hatch cover may be opened and closed manually.

"Inside the airlock there are two movie cameras for filming the cosmonaut's entry into the airlock and his exit from it, a lighting system, control panel and airlock control systems.

"A movie camera is installed outside the airlock to film the cosmonaut in outer space. Outside the airlock there are also spare air cylinders for pressurizing the airlock and emergency oxygen cylinders.

"After the completion of the space walk program the airlock is separated from the spaceship.

"A special space suit was designed to enable a cosmonaut to walk in space.

"The space suit has a sandwich-type hermetically sealed skin, designed to maintain surplus pressure inside the space suit, necessary for normal activities while the cosmonaut is performing space walk.

"The helmet of the space suit is of double hermetically sealed design and has a protective filter to enable the cosmonaut to see without risk of damage to the eyes by solar rays.

"The space suit has a special outer coating for protecting the cosmonaut from the heat of the sun rays.

"Both crew members were equipped with such space suits so that the flight commander could render assistance to the copilot in outer space if needed.

"The space suits are equipped with ventilation and oxygen supply systems to maintain necessary living conditions for the cosmonauts, both inside the spaceship and when walking in outer space.

"When the cosmonauts are inside the cockpit the space suits are ventilated with the air in the cockpit. When the cockpit is depressurized a system that ventilates the space suit with compressed oxygen and air, supplies of which are provided on board the ship, is actuated automatically.

"While the copilot is in space he is supplied with oxygen from cylinders in a backpack, strapped to the space suit.

"The flight commander controls the airlock from a control panel inside the cockpit.

"If need be the basic airlock operations may be controlled by the copilot at a control panel inside the airlock.

"When the copilot walks in open space he is secured by means of a special tether, which enables him to depart from the exit of the airlock of the spaceship to a distance of 5.35 meters.

"The spaceship may be controlled both automatically and by the crew, using manual control."

In the next section of the "Affidavit" we read:

"Medical observation of the health of cosmonauts P. I. Belyayev and A. A. Leonov was accomplished through telemetry channels on the basis of the readings of the following medical parameters:

electrocardiogram;

pneumogram;

seismocardiogram;

electrooculogram.

"At the same time there is a special transmitter, operating in the continuous mode, for monitoring the pulse rate and respiration of each cosmonaut on an alternate basis. In addition, cosmonaut A. A. Leonov's temperature was monitored in the right axillary area. Cosmonaut P. I. Belyayev, using a special light display, monitored cosmonaut A. A. Leonov's pulse and respiration while the latter was inside the spaceship, in the airlock and in outer space."

Physiological studies during space flights are very important. The health of a cosmonaut throughout a space flight is monitored not only by transducer devices, but also by experienced physiologists. This must be done so that assistance may be rendered to a cosmonaut if need be, and in order to gather as much scientific information as possible about the influence of space flight factors on the human body.

The condition of the heart and the rhythm of contractions of the heart are monitored on the basis of electrocardiograms. Pneumograms determine the respiratory motion of the rib cage, i.e., the frequency and amplitude of respiration. Electroencephalogram readings determine the activity of the brain. By analyzing electroencephalograms it is possible to determine whether a cosmonaut is awake or asleep, excited or tired, and also the reactions of the central nervous system to various stimuli.

In other words the objective state of a cosmonaut can be determined easily on the basis of his electroencephalogram during various periods of space flight.

By examining an electrooculogram the physician can study the motor activity of the eyes and discover various impairments of the vestibular system.

The seismocardiogram enables the physician to determine local g-forces that act upon the rib cage of a cosmonaut during launch and landing.

The condition of the cosmonauts is demonstrated graphically in the table below on the basis of two biological indices: pulse rate and respiration frequency [2].

Segment of flight	Pulse rate		Respiration frequency	
	Belyayev	Leonov	Belyayev	Leonov
Prelaunch	80	86	22	20
Orbital insertion				
at beginning of insertion	86	90	22	24
at end of insertion	88	84	22	22
Orbital flight				
1st orbit	92	95	24	24
2d orbit	93	143	22	31
4th orbit	81	70	18	16
7th orbit	74	58	16	18
13th orbit	80	70	18	18
17th orbit	110	80	22	18
Retro segment	109	104	16	24
End of re-entry segment	151	145	26	23

The state of the respiratory, circulatory, vestibular and central nervous systems did not deviate from normal. However, during A. A. Leonov's space walk his pulse rate increased to 143 and his respiration frequency to 31 per minute, which is attributed to increased physical and neuroemotional stress.

We leaf through the next pages of the "Affidavit" and read: "Brief description of instruments for measuring orbital parameters, measurement accuracy and calibration curves."

Measurements were taken at tracking stations, located in the USSR along the flight path of the satellite. The tracking stations are equipped with radar, operating in the satellite transponder mode.

The document ends with the reports of aviator-cosmonauts of the USSR P. I. Belyayev and A. A. Leonov about their flight aboard "Voskhod-2" and the completion of their flight program.

The "Records Affidavit..." was forwarded to Paris in May 1965 to the International Aviation Federation (FAI).

The regularly scheduled meeting of the International Astronautics Commission of FAI was held on 18 June of the same year, at which the proposal offered by the Soviet Union to record the new space records associated with the space walk was approved.

A resolution to amend the existing sports code with a new category of records in the orbital flight class was adopted at that meeting. The amendments consisted of statements concerning the conditions under which the world record space walk time is established.

It is stated in the FAI resolution that the duration of a space walk is the time spent by an astronaut completely outside the spaceship, when the astronaut is using a self-contained life support system and is not connected in this respect to the spaceship. It is further stated that each new record, confirmed in this category, must exceed the previous record by at least 25%.

Thus, after the flight of "Voskhod-2" and the world's first space walk FAI adopted the resolution on the registration of space records.

On 20 October 1965 FAI confirmed two world records: maximum space flight altitude of 497.7 km and space walk time of 12 minutes 09 seconds, set on 18 March 1965 by the Soviet cosmonauts P. I. Belyayev and A. A. Leonov with the spaceship "Voskhod-2."

The USSR Federation of Aviation Sports receivedffrom Paris the following two telegrams on this subject:

INTERNATIONAL AVIATION FEDERATION
(FAI)

Address: Galileo St. 6 (XVI)

Telephone: 553-76-40
Telegraph address: FEDAERO -- Paris

Paris, 20 October 1965

President of
USSR Federation of Aviation Sports
Moscow D-362, Tushino

Dear Mr. President:

We are honored to inform you that we have confirmed the following record and have entered it in the list of official FAI records:

WORLD RECORD ALTITUDE IN SPACE

P. I. Belyayev (USSR)
A. A. Leonov
aboard "Voskhod-2"
18 and 19 March 1965

497.7 km

Respectfully,
C. Ennikar, General Director

INTERNATIONAL AVIATION FEDERATION
(FAI)

Address: Galileo St. 6 (XVI)

Telephone: 553-76-40
Telegraph address: FEDAERO -- Paris

Paris, 20 October 1965

President of
USSR Federation of Aviation Sports
Moscow D-362, Tushino

Dear Mr. President:

We are honored to inform you that we have approved the following record and have entered it in the list of official FAI records:

WORLD RECORD SPACE WALK TIME

A. A. Leonov (USSR)
18 March 1965 — 12 minutes 9 seconds

Respectfully,
C. Ennikar, General Director

An FAI council was held in Paris in October 1965, at which the question concerning the presentation of high international awards for outstanding achievements in aviation, aviation sports and astronautics was discussed.

The council unanimously voted to award the International Gold Medal "Cosmos" to aviator-cosmonaut of the USSR Aleksey Leonov for the world's first space walk during the flight of the Soviet spaceship "Voskhod-2" on 18 March 1965. For setting the world record maximum space flight altitude aboard the spaceship "Voskhod-2" Soviet cosmonauts P. I. Belyayev and A. A. Leonov were awarded honorary diplomas and medals by FAI.

The 59th General Conference of the International Aviation Federation was conducted in Santiago (Chile) on 29 November 1966. In keeping with long established tradition at the General Conferences of the aviation federation, outstanding achievements in aviation and astronautics are honored with high awards. Soviet aviator-cosmonaut A. A. Leonov, who attended that conference as guest of honor, for performing the world's first experiment outside of a spaceship in open space, which is of great scientific importance, received the highest award of FAI, the "Cosmos" Gold Medal.

For setting a world record maximum space flight altitude aboard "Voskhod-2," A. A. Leonov was awarded a medal and honorary diploma. The FAI medal and diploma were presented to cosmonaut P. I. Belyayev in Moscow by President of FAI V. K. Kokkinaki.

The first step into space, which Yuriy Alekseyevich Gagarin took, was the most difficult. After that many Soviet and American astronauts flew in space. To replace "Vostok" and "Gemini" came new and better spaceships, in

which astronauts flew around the earth and to the moon. But the people of our planet will never forget the memorable date of 4 October 1957. It was on that day that a powerful Soviet rocket launched the first artificial satellite into earth orbit, heralding to the entire world the birth of a new age in the scientific-technical progress of the human race.

Our country became a pioneer in space exploration, and her scientists, engineers, workers and cosmonauts were the first to pave the way for mankind into space.

And the flight of aviator-cosmonauts of the USSR P. I. Belyayev and A. A. Leonov aboard the Soviet spaceship "Voskhod-2" represents an important link in this chain of scientific events.

THE FEAT ATTRACTS WORLDWIDE ADMIRATION

As soon as Moscow radio announced the completion in the USSR of the scientific-technical experiment by the crew of the Soviet spaceship "Voskhod-2," radio and television transmissions were interrupted in all countries of the world. "Flash" announcements concerning this global historical event were immediately transmitted on all continents and in various languages.

NEW YORK. The American press agencies AP and UPI interrupted their usual transmissions to announce the most urgent news report concerning the orbital insertion of the Soviet spaceship "Voskhod-2," manned by aviator-cosmonauts Pavel Belyayev and Aleksey Leonov.

AP added that word about the orbiting of "Voskhod-2" arrived just 5 days before the planned launch by the United States of itsffirst two-man spaceship, which was scheduled to make three orbits around the earth.

WARSAW. Millions of Polish viewers cast eyes skyward, where the new Soviet spaceship, carrying two courageous space explorers, was flying. The minute the radio announced the successful launch of the spaceship IZVESTIYA correspondent in Poland, Yu. Ponomarenko, called the earth satellite observation station in Warsaw and asked Professor Matiy Belitskiy to comment on the new achievement of Soviet science.

"In this remarkable flight," replied Professor M. Belitskiy, "I, as a scientist, see great and qualitatively new problems. A man has left the spaceship and gone into space for the first time in history. That is astounding!

"Our instruments right now are locked on the space path of the ship. We are completely confident of seeing the Soviet ship and acquiring additional scientific data. I was happy, for example, to report to Valery Bykovskiy during his visit to Poland, that we watched his flight from earth.

"Today we again share with Soviet scientists the pleasure of this feat."

LONDON. As soon as Moscow reported the launch of the scheduled spaceship, aboard which were flying the brave Soviet cosmonauts Col Belyayev and Lt Col Leonov, the Reuter News Agency immediately transmitted an urgent telegram to the British capital, and the BBC broadcast it without delay.

The Reuters agency emphasized that "Having launched their new spaceship, the Russians again were ahead of the United States in the space race."

The London evening papers began reprinting their front pages. The event was reported by telephone from the editorial offices of the newspapers EVENING STANDARD and EVENING NEWS.

BERLIN. News of the launch of "Voskhod-2" spread quickly through the capital of the GDR. Radio stations of the republic broadcast the first details of the flight and broadcast biographies of the crew members of the spaceship for the listeners. The evening papers prepared their headlines for the report from Moscow.

Professor Johannes Wempe, director of the Potsdam Observatory, declared: "We praise the accomplishments of the Soviet working people, engineers, scientists and all who took part in the preparation of this flight. The launch of 'Voskhod-2' is convincing proof that Soviet science continues to lead the way to the exploration of the universe."

PARIS. The teletype of the news agency France Press, clacking out a scheduled important report from South Vietnam, suddenly stopped in the middle of a word and then began to print:""Flash -- the Soviet Union has launched a spaceship with two cosmonauts on board." That was followed by the official TASS report with details about the launch.

"Two Russians are in space. According to available information everything is proceeding normally. We wish them bon voyage," announced the Paris radio stations to millions of their listeners.

COPENHAGEN. As soon as word reached Denmark about the successful launch in the Soviet Union of the spaceship "Voskhod-2" with cosmonauts P. Belyayev and A. Leonov on board, a TASS correspondent telephoned the Danish artist Herluf Bidstrup, laureate of the International Lenin Prize: "For the Strengthening of Peace between Nations."

"I am very happy about the new and great achievement of Soviet science," said Bidstrup in an emotional voice. "I am confident the flight will be a success and the cosmonauts will return safely to their homeland. I wish to congratulate the Soviet people on their new victory in the exploration of space. I wish the cosmonauts success."

OSLO. "We in Norway are following with great interest the flight of the new Soviet satellite 'Voskhod-2,'" declared Prime Minister of Norway E. Gerhardtsen to the TASS correspondent there. "It was especially interesting to learn about the unprecedented experiment in which one of the cosmonauts got out of the spaceship."

DJAKARTA. "The scientific community of Indonesia applauds the new Soviet victory in space exploration," declared the famous Indonesian scientist, Doctor Firdaus Amir. "We warmly congratulate Soviet scientists on their brilliant achievement. The flight of 'Voskhod-2' is truly a tribute to Soviet science. We wish the cosmonauts a safe landing."

Many congratulatory messages, expressing admiration for the new and remarkable triumph of our science, technology and for the feat of the cosmonauts, were addressed to the Presidium of the Supreme Soviet of the USSR, Soviet government and to P. I. Belyayev and A. A. Leonov personally.

"We are all deeply impressed by the exploit of Lt Col Aleksey Leonov, the first man ever to leave a spaceship and return safely to it," wrote President of the United States L. Johnson.

"It gives me great satisfaction," he continued, "to express on behalf of the citizens of the United States sincere congratulations and best wishes to the cosmonauts and scientists and to all others who contributed to this outstanding achievement."

UN Secretary-General U Thant sent the following telegram to A. N. Kosygin:

"It gives me great pleasure to express to you and the Soviet people sincere congratulations on your recent outstanding accomplishment in the peaceful exploration of space. I send my personal congratulations to cosmonauts Pavel Belyayev and Aleksey Leonov, and to the group of Soviet scientists and engineers who made this historic event possible."

"Dear Pavel Belyayev and Aleksey Leonov," wrote comrade Todor Zhivkov, first secretary of the Central Committee of the Bulgarian Communist Party. "Please accept most sincere congratulations, both from us communists and from all the workers of the People's Republic of Bulgaria, who along with all mankind joyfully greet the remarkable flight of the spaceship 'Voskhod-2.' By your accomplishment you have opened a new stage in space exploration and bring us closer to the realization of the age-old dream of man flying to other planets.

"By your successful flight you prove once again the superiority of Soviet science and technology, celebrate a new triumph of Soviet creative genius and enhance the prestige of the omnipotent country, the Soviet Union, and of the great party of Lenin.

"The flight of 'Voskhod-2' is a flight for the benefit of peace and progress, a flight for the benefit of communism.

"I congratulate you once again on your successful landing and wish you new successes in your noble cause. Best wishes to you and your families. I embrace you as brothers."

It is not possible to include here all the telegrams and letters which the cosmonauts and our country received from many countries of the world. They are too many. They were sent by government officials, scientists, writers, poets, composers, scholars, workers and peasants. They express sincere congratulations to the party, government, people and to cosmonauts P. I. Belyayev and A. A. Leonov, and also recognition of the great contributions of Soviet science to space exploration in the interests of peace and progress.

Thousands of letters and telegrams, expressing great warmth, sincerity and pride for our country, were sent by Soviet staffs and individual citizens to cosmonauts Belyayev and Leonov. Here are some of them:

"Yet another historical event has taken place. For the first time in world history a Soviet man, aviator-cosmonaut Lt Col A. A. Leonov, has accomplished an unprecedented feat: he walked out of the 'Voskhod-2' spaceship into boundless space.

"This shaking event coincided with the 94th anniversary of the Paris commune. Karl Marx was enraptured by the heroism of the Paris communists, who, in his words, invaded the heavens. Our Soviet people, not figuratively, but literally continue to invade the skies and explore the depths of the universe.

"From the bottom of my heart I sincerely congratulate our cosmonaut heroes and wish them complete success in the completion of their flight program and safe return to native soil."

Yelena Kravchenko
Member of CPSU since 1903

Moscow, 18 March

"Our Soviet people are in space once again. This news spread like wildfire through the mining city. For us, people of the Kuzbass, the joy is two-fold. In the crew of 'Voskhod-2,' along with flight commander Pavel Ivanovich Belyayev, is our countryman Aleksey Arkhipovich Leonov.

"We are proud of this courageous Kuzbass fellow, the world's first space walker!"

N. Kochetkov
Deputy of the Supreme Soviet RSFSR,
Foreman of Fast Excavation Crew,
Mine No. 3-3-bis

Prokop'yevsk,
Kuzbass

"For the first time in world history a man, a citizen of the Soviet Union, has left a spaceship to meet the expanses of the Universe face to face. We aviators, probably more clearly and completely than anybody else, understand the grandeur of this new step toward the exploration of space.

"It is my infinite good fortune that this event took place on the eve of the 20th anniversary of the victory of the Soviet people in the Great Patriotic War. Our heroic cosmonauts have made an invaluable contribution not only to our country, but to all peaceloving people.

"The older generation of Soviet aviators can be proud of their successors, the cosmonauts, the ranks of which today include Pavel Belyayev and Aleksey Leonov. The scepter has been passed on to strong hands. By their feat they again honor our beloved country. In behalf of my colleagues, veterans of the great war with fascism, I sincerely congratulate the brave space explorers and wish them a safe return to earth."

Marina Chechneva
Hero of the Soviet Union

"It seems to me that the tremendous feeling of ecstasyaand pride for the new triumph of the creative genius of mankind can be conveyed especially completely by music. Each success of the Soviet peoples in the exploration of interstellar space is for us composers a boundless source of inspiration to sing and write songs that are worthy of our time, the age of space hymns.

"To the man who first walked in space, Lt Col Leonov, I dedicate a new song about the fruitfulness of the great concepts of communism.

"In behalf of the creative intelligentsia of Tadzhikistan I warmly congratulate the cosmonauts. We await the heroes on native soil!"

Sh. Sayfiddinov
Chairman of the Administration of
the Union of Composers of Tadzhikistan

Dushanbe

"The great staff of scientists of the Ukrainian Academy of Sciences, with a sense of pride for our country, learned about the new and great step in space exploration, the launch into earth orbit of the multiplace manned spaceship 'Voskhod-2.'

"The increasingly complicated scientific experiments and studies that are conducted with each new launch of spaceships are excellent proof of the successes of Soviet science and technology. The world's first space walk opens a new era in space exploration.

"These achievements are the result of the inspired labor of the entire Soviet people -- engineers, scientists and workers, representatives of many fields of science and technology.

"We send heartfelt congratulations to the courageous crew of the spaceship 'Voskhod-2' and wish them a successful completion of their difficult and important program.

"Happy landing, our dear compatriots!"

Academician V. Glushkov

The walk by man in open space isaan unprecedented feat, which demonstrates that man cannnot only fly in space, but also work directly in space outside of the spaceship. The solution of this difficult problem marked the beginning of a qualitatively new phase of cosmonautics.

S. Vernov, Associate Member of the USSR Academy of Sciences, writes the following concerning the significance of this scientific experiment and the promises of space exploration:

"The rapid development of science and technology opens ever newer horizons to mankind. That which yesterdaysseemed to be an unattainable dream is today a reality.

"In 1957 the entire world praised the Soviet Union, its scientists, designers and workers, who built the first artificial earth satellite. This marked the beginning of the exploration of near-earth space. During the 7.5 years that have passed since then we have been leaders in space. Often the world has applauded us and the names of our cosmonaut heroes are known to all earthlings.

"Today we celebrate a new space victory by the Soviet Union. The first man has walked in 'outer' space.

"No matter how remarkable our spaceships are, there are still problems that cannot be solved by remaining inside them. Large space stations will be built in the future. The 'builders,' of course, must work outside of a spaceship. Only by freely maneuvering in space can man examine the complex constructions of these gigantic facilities. Orbital stations will help us to solve many scientific problems. They may also become 'intermediate cosmodromes,' from which spaceships will travel to the Moon, Mars and Venus.

"Man's entry into space from a spaceship is an extremely difficult problem. We are fortunate that it was solved successfully. Indeed, it was necessary to overcome exceptional difficulties in order to achieve this new victory on the road to space exploration...

"We must look into the future. Undoubtedly the day is not far away when cosmonauts will often leave their ship. How long of a 'work day' will be tolerable in such a case? Long-term measurements of various forms of radiation during the flights of satellites of the 'Elektron' type have established substantial fluctuations of the intensity of radiation in space...

"Suppose a sharp increase in radiation is predicted. This means, first of all, that all operations outside the spaceship must be forbidden. Would the spaceship have to return to earth? It seems to me that future spaceships will probably be equipped in such a way as to avoid that. But each large spaceship will probably be equipped with special radiation shelters, rooms protected from radiation by thick walls. In such radiation shelters astronauts will sit out 'cosmic storms.' To be able to forecast the radiation situation and to construct efficient radiation shelters of spaceships it will be necessary to conduct extensive studies of the radiation belts of the earth and of processes that take place on the sun and in interplanetary space.

"Though we take great pride in our successes in space exploration, we nevertheless must remember the great opportunities that space flight holds forth for humanity. Space exploration should improve the life of our citizens.

"The exploration of space will give us a better understanding of how our world was created. That in itself is very important. It is difficult to foresee what the unknown conceals. We can expect especially great results from flights to Mars and Venus. Much work was expended in order to gain an understanding of the history of our planet. This labor was not wasted. We use the riches of the earth every day. It is hard to imagine modern life, science and technology without the extensive utilization of natural resources. Great investments are made in the search for minerals. However they more than pay off when the earth yields to us the storehouses concealed within her depths. The search for natural resources would be even more effective if we could 'peek' into the history of our planet. It is this very opportunity that the exploration of the other planets of our solar system will provide for us. Throughout the history of the development of the planets some of them most probably overtook others. Therefore, it may be that by studying Mars we will learn in what state the earth was many many millions of years ago. The importance of such studies may be enormous, not only for science, but also for day to day life and for the improvement of the standard of living of the human race.

"The potential promises of the analysis of the earth's structure by comparing it with the structure of other planets, even very roughly, are obvious. But if new forms of life are discovered on other planets, then it is impossible to conjecture to what enormous changes this will lead in human life. We feel that life evolved on our planet billions of years ago. Gradual evolution led to the appearance of man. This entire process took place under completely defined physico-chemical conditions. Had these conditions been different the result might also have been different. The discovery of extra terrestrial forms of life will lead to a radical change in our ideas of the world around us. Such an event will also bring numerous unforeseen practical applications...

"The exploration of space in the shortest period of time has led to many discoveries...

"There can be no doubt that by investigating space it will be possible to find the key to the solution of many geophysical problems" [11].

It should be mentioned briefly in conclusion that the satellites that are flying around the earth already are bestowing great benefits upon mankind. There have been difficulties, related to weather forecasts. The entire earth is criss-crossed by a network of meteorological stations. However, this network is not enough. Satellites flying above the earth greatly complement the network of meteorological stations.

Radio and television play an important role in human life. The earth is surrounded by the ionosphere. Radio waves, reflected by the ionosphere, easily bend around the earth and provide radio communications between continents. However, the ionosphere is too weak for television. The wavelengths on which television transmissions are propagated pass unimpeded through the ionosphere into interplanetary space. By using satellites above the earth it is possible to hang "mirrors" that reflect television signals.

The above examples illustrate the broad horizons that are being opened by space exploration.

We wish our designers new successes in the building of spaceships and our heroic cosmonauts new flights.

It must be added in conclusion that the flight of the spaceship "Voskhod-2" gained worldwide international recognition as a new outstanding achievement by Soviet scientists who are invading space. It is an important step toward the understanding of the new and unknown. And we are gratified by the fact that this was done in our country by Soviet scientists, engineers, workers and cosmonauts.

The first step has been taken to the construction of orbital stations, "space settlements" as our visionary compatriot K. E. Tsiolkovskiy called them. The first steps, taken by A. Leonov in space, herald the beginning of a great trend, the active creativity of man in space, a trend that will lead to the peaceful mastery of the universe.

THE FEAT IS DUPLICATED

On 3 June 1965, 2.5 months after the world's first space walk by a Soviet cosmonaut, the United States launched into space by a "Titan-2" rocket the two-place "Gemini-4" satellite, manned by astronauts J. McDivitt and E. White. At 1945 hours Moscow time of 3 June, after the cockpit was depressurized, astronaut White opened the hatch and got out of it into open space. Like Leonov, he too was attached to the ship by a tether. But White did not go into space through an airlock as Leonov did, but directly out of the cockpit of the "Gemini-4" satellite through the entrance hatch. White spent 20 minutes outside the ship. At 2005 hours he went back into the spaceship. It took 25 minutes to batten down the hatch. In all probability the ratchet spring froze up under the conditions of cosmic vacuum. Astronauts McDivitt and White exerted much physical effort to correct this troublesome and dangerous defect. Astronaut White, who repeated Soviet cosmonaut Leonov's experiment, was the first U.S. astronaut to complete this important scientific-technical experiment.

At 0041:02 hours Moscow time of 16 March 1966 the United States launched into space the "Gemini-8" spaceship, flown by astronauts N. Armstrong and D. Scott. In addition to the planned flight program of docking the satellite with an "Agena" rocket, the mission included a space walk by astronaut D. Scott. But because of a malfunction of the guidance system D. Scott's space walk had to be abandoned. The "Gemini-8" spaceship made a premature emergency landing in the 7th orbit.

On 3 June 1966 a "Titan-2" booster rocket lifted the U.S. spaceship "Gemini-9" into near-earth orbit. The ship was flown by astronauts T. Stafford and E. Cernan.

On the third day of the flight Cernan opened the hatch, mounted a movie camera on the outside of the spaceship and at 1808 hours Moscow time went out into space. The astronaut began to move around the spaceship and perform other maneuvers, connected to the spaceship by a 7.6-meter tether. But he failed to complete his program, since the tether "floated" and got wrapped around the astronaut. Before stepping out into space Cernan's pulse rate was 80-90 beats per minute. As soon as he opened the hatch his pulse reached 155, and during his space walk it varied from 130 to 170 beats per minute.

Two hours five minutes later Cernan returned to the spaceship. Cernan experienced his highest pulse rate (180) while he was closing the hatch after returning to his place. Before closing the hatch Cernan dropped the cartridge of film, on which his space walk was recorded. The flight of "Gemini-9" lasted 72 hours 21 minutes 14 seconds.

On 18 July 1966, a month and a half after the space flight of "Gemini-9," the U.S. spaceship "Gemini-10" with astronauts J. Young and M. Collins, was launched into earth orbit. This scheduled flight was supposed to perform two experiments -- docking with the "Agena-9" rocket and a space walk by astronaut Collins. At 23 hours 27 minutes after launch an experiment was undertaken to photograph space from the open hatch of the spaceship. The astronaut stood up on the seat of his couch, pulled himself through the hatch to the shoulders and began taking pictures. Collins immediately experienced strong irritation of the eyes (profuse lacrimation) and was forced to terminate the experiment; the hatch was closed 35 minutes later.

Collins performed a space walk on 20 July. After crawling through the hatch he deployed a hand rail on the body of the spaceship in the working position. Clinging to this hand rail, he maneuvered himself to an auxiliary compartment containing a cylinder of compressed nitrogen for the thruster system. Collins then removed from the body of the spaceship a rack of micrometeorite traps and handed it to Young, after which he moved to the "Agena-8" rocket. Collins had great difficulty performing these operations. While he was removing the micrometeorite trap rack from the spaceship he lost his grip on a movie camera and it "floated" away from the astronaut.

Thirty minutes after the beginning of the experiment Collins was instructed from earth to return to the cockpit, since Young had overexpended propellant while keeping the satellite close to the rocket. Eight minutes after receiving the command the astronaut returned to the cockpit and closed the hatch behind him. Thus he spent 38 minutes in outer space.

During that flight Collins used a thruster to enable him to move around in outer space. A few minutes later Collins and Young opened the hatch of their spaceship and began to discard unnecessary equipment after the space walk experiment. In the process the micrometeorite trap rack and the flight log and program "floated" out of the cockpit along with the refuse. The flight lasted 70 hours 46 minutes 45 seconds.

At 1842 hours Moscow time on 12 September 1966 the United States launched the spaceship "Gemini-11" with two astronauts aboard. The crew consisted of flight commander C. Conrad and R. Gordon. The flight program consisted of scientific experiments in space and a space walk by astronaut R. Gordon.

After the first days of the flight the astronauts began to prepare for Gordon's space walk. After pressurizing his space suit Gordon sensed a great restriction of movement. He was able to lift his arms only with great difficulty. He was unable to place extra protective visors on his

space helmet by himself, and this was finally accomplished 30 minutes later with Conrad's help, and during that half hour period the astronauts had to rest three times.

At 23 hours 56 minutes after launch, as "Gemini-11" and the "Agena-11" rocket docked to it were passing over the Hawaiian islands, Gordon opened the hatch and stood on his couch seat. Conrad held him by the legs. Then Gordon installed a movie camera on the outside of the spaceship, crawled through the hatch and began to move along "Gemini-11" to "Agena-11." He gave himself a rest after 9 minutes. His pulse during that time was 162-180 beats per minute. Gordon perspired profusely and perspiration got into his right eye. Conrad ordered him to return to the cockpit. Gordon re-entered the spaceship 38 minutes later, took his seat, and the hatch was closed 6 minutes later. The space walk experiment lasted only 44 minutes instead of the scheduled 107 minutes.

The flight of "Gemini-11" lasted 71 hours 17 minutes 08 seconds.

The last flight of the U.S. program "Gemini" was the flight of "Gemini-12," launched from Cape Kennedy at 0456 hours Moscow time on 11 November 1966. The ship was flown by astronauts J. Lovell and E. Aldrin.

According to the flight program the astronauts were supposed to dock the spaceship to an "Agena" rocket and astronaut E. Aldrin was supposed to leave the ship and perform operations to moor "Gemini-12" to the rocket with a special 30-meter long mooring line. In the 13th orbit E. Aldrin opened the hatch of the spaceship and photographed the heavens, the moon and earth for 2.5 hours. After two days of flight Aldrin climbed out of the spaceship and walked in open space for 2 hours 09 minutes 30 seconds. While outside the ship Aldrin secured the satellite to the "Agena" rocket with a 30-meter tether. During this time the astronaut was tied to "Gemini-12" by an 8-meter long tether.

Some time later the hatch was reopened. Aldrin, standing on his seat, spent 59 minutes photographing stars and the sunrise and also conducted other experiments.

Thus concluded the flight program of "Gemini-12." The spaceship spent 94 hours 35 minutes in space.

After the completion of the space walk experiments the task of rendezvousing and connecting spaceships in space, known as docking, was added to the agenda.

This task was performed brilliantly by our Soviet scientists on 30 October 1967. On that day two earth satellites, "Kosmos-186" and "Kosmos-188," for the first time in the history of space exploration, by means of special propulsion systems and an entire complex of electronic systems and computers, were brought close together and docked automatically, after which free flight was started in space at an altitude of 276 km.

"Kosmos-186" and "Kosmos-188" continued to fly for 3 hours 30 minutes in the docked state. Automatic undocking of the satellites was accomplished by command from earth. The satellites re-entered the earth's atmosphere some time later.

On 15 April 1968 the second automatic docking of the earth satellites "Kosmos-212" and "Kosmos-213" was accomplished in orbit, and these satellites were in the docked condition for 3 hours 50 minutes.

These experiments confirmed the feasibility of assembling in orbit large space stations for research purposes and as intermediate stations and unique docking facilities for interplanetary spaceships. In time crews will be exchanged there and spaceships will be fueled and will take on supplies of food, hardware, etc.

In early 1969 our country planned to conduct a most difficult space experiment with two manned spaceships, "Soyuz-4" and "Soyuz-5." According to the flight program the spaceships would be docked in space, i.e., the world's first experimental space station would be created, and two cosmonauts, during the course of the flight, would move from one satellite to the other through open space.

At 1039 hours Moscow time on 14 January 1969 "Soyuz-4," flown by cosmonaut of the USSR V. A. Shatalov, was launched from Baykonur cosmodrome. The perigee of the orbit was 173 km and the apogee was 225 km. After the orbit was corrected in the 4th orbit the perigee was 207 km and the apogee was 237 km.

The crew of the second satellite, "Soyuz-5," consisted of flight commander B. V. Volynov, flight engineer A. S. Yeliseyev and research engineer Ye. V. Khrunov. They were launched from Baykonur cosmodrome at 1414 hours on 15 January 1969.

"Soyuz-4" was passing over Baykonur as "Soyuz-5" was being launched. Its commander, V. Shatalov, clearly saw the insertion of the new ship through his windows. Group flight had started.

On the morning of 16 January the crews of the spaceships received permission to conduct the experiment. The ships were first maneuvered to bring them closer together. Then the ship radar tracking and guidance system was turned on, ensuring automatic rendezvous. For these purposes "Soyuz-4" was equipped with an "active" docking system, and "Soyuz-5" with a "passive" one. Some time later the "active" spaceship began to approach the "passive" satellite. The distance between the satellites was only 100 meters. "Soyuz-4" commander V. A. Shatalov took the controls. He controlled the operation of the satellite's thrusters, controlled linear speed and oriented the satellite for more exact approach and docking with "Soyuz-5." V. A. Shatalov reported that "Soyuz-5" was 40 meters, and then 20 meters away. Finally the long-awaited moment arrived. At 1120 hours of 16 January 1969 two manned spaceships, "Soyuz-4" and "Soyuz-5," were docked in space. The satellites were flying above the Soviet Union during that time.

Thus the world's first experimental space station, consisting of two cockpits, two orbital compartments for scientific research and rest and two instrument compartments with a useful space of 18 cubic meters, was assembled and began to function in orbit around the earth. The total weight of the space station was 12,924 kg.

The next important experiment of this flight was a space walk by Yevgeniy Khrunov and Aleksey Yeliseyev and their transit to "Soyuz-4." As soon as the orbital space station began to function cosmonauts Ye. V. Khrunov and A. S. Yeliseyev, now in the orbital compartment along with B. V. Volynov, put on their space suits with his help. B. V. Volynov then went into the crew compartment, closed the hatch behind him and depressurized the orbital compartment. The exit hatch was then opened. Khrunov got out first, followed by Yeliseyev. The cosmonauts inspected the station and performed scientific experiments. By then V. A. Shatalov had already opened the entrance hatch in the second orbital compartment. Vladimir Shatalov met his friends and helped them remove their space suits.

The orbital space station continued to fly until 1555 hours of 16 January. At that time "Soyuz-4" and "Soyuz-5" were undocked.

"Soyuz-4," carrying cosmonauts V. A. Shatalov, Ye. V. Khrunov and A. S. Yeliseyev, landed on 17 January. "Soyuz-5" returned to earth with cosmonaut B. V. Volynov on 18 January.

Cosmonauts Ye. Khrunov and A. Yeliseyev were outside the spaceship simultaneously for 37 minutes, and they spent about 1 hour under conditions of cosmic vacuum.

The International Aviation Federation commended the feat of Soviet cosmonauts V. A. Shatalov, B. V. Volynov, Ye. V. Khrunov and A. S. Yeliseyev. They were all awarded FAI diplomas and medals for their outstanding scientific-technical accomplishments and for setting absolute world records as the result of the flights of spaceships "Soyuz-4" and "Soyuz-5."

During that flight absolute world records were set for the maximum total weight of the spaceships "Soyuz-4" and "Soyuz-5" in the docked condition (the total weight of the space station was 12,924 kg), flight time of these ships in the docked condition of 4 hours 33 minutes 49 seconds, and time of a simultaneous space walk by two cosmonauts (Ye. Khrunov and A. Yeliseyev) of 37 minutes.

The experimental results of the flights of "Soyuz-4" and "Soyuz-5" received high marks and heralded the beginning of a new phase of space research.

The flights of manned spaceships of the "Apollo" program began in the United States in 1968.

The "Apollo" flight program included not only the landing of astronauts on the lunar surface and their exploration of the lunar surface, but also a

space walk during the time of the moon-earth transit leg of the flight. Therefore the crew of "Apollo-9," during the flight, not only had to check the operation of all systems of the main crew compartment of the spaceship and the lunar module, but one of the astronauts had to go out into open space.

The launch of "Apollo-9" into near-earth orbit took place on 3 March 1969. Astronauts J. McDivitt, D. Scott and R. Schweickart were aboard the spaceship. On the second day of the flight the service propulsion engine was fired twice and the spaceship went into a higher orbit. The next day first Schweickart, and then McDivitt moved from the crew compartment into the cockpit of the lunar module through an internal passageway. They returned to the crew compartment some time later. They repeated this operation at the beginning of the 4th day of the flight. After a few minutes Schweickart climbed from the hatch onto a platform and, clinging to the hand rail, spent more than 30 minutes in outer space while the spaceship was in the shadow of the earth. The astronaut then returned to the spaceship. The flight of "Apollo-9" around the earth lasted 241 hours.

The flight to the moon and the stepping down of two American astronauts onto its surface were great events in the history of space exploration.

At 1632 hours Moscow time of 16 July 1969 the American spaceship "Apollo-11" with the three astronauts N. Armstrong, M. Collins and E. Aldrin, was launched from Cape Kennedy and took a heading toward the moon.

On 19 July the spaceship headed out for lunar orbit. After firing of the service propulsion engine and reduction of velocity the lunar module of "Apollo-11," with astronauts Armstrong and Aldrin aboard, began independent flight to the moon.

At 2317:32 hours of 20 July 1969 Armstrong and Aldrin, standing in the lunar module, landed on the lunar surface. First Armstrong, followed by Aldrin, emerged from the cockpit and began to walk around on the moon, completing a program of experiments. Armstrong was on the lunar surface outside of the spaceship for 2 hours 31 minutes 40 seconds, and Aldrin for 1 hour 46 minutes. Thus astronaut Armstrong, wearing a space suit with a self-contained life support system, set an absolute world record time on the moon in the vacuum of space outside of the spaceship.

The total time that these two courageous U.S. astronauts spent on the moon was 21 hours 36 minutes 21 seconds.

After the flights of the U.S. spaceships "Apollos-12, 13 and 14," the flight programs of which did not call for space walks, "Apollo-15," with astronauts D. Scott, A. Worden and J. Irwin, was launched from Cape Kennedy to the moon on 26 July 1971.

At 0116 hours Moscow time on 31 July the lunar module with astronauts Irwin and Scott landed on the surface of the moon. Three times the astronauts

left the shelter of the module and explored the surface of the moon. The total time they spent on the moon was 18 hours 37 minutes.

After taking off from the moon and entering an earth transit trajectory astronaut Worden began to prepare for a space walk. On 5 August Worden completed and 18 minutesspace walk. He transferred two film cartridges from the engine compartment to the cockpit and performed other planned operations.

"Apollo-16" was launched to the moon at 2054 hours Moscow time on 16 April 1972. Aboard the ship were astronauts J. Young, T. Mattingly and C. Duke.

On 19 April the spaceship entered the gravitational field of the moon and at 2323 hours entered a selenocentric orbit.

On 21 April, at 0524 hours, the lunar module landed. After a brief rest Young stepped onto the surface of the moon, followed by Duke. The astronauts completed three sessions on the surface of the moon, lasting a total of 20 hours 14 minutes. They traveled a distance of 27.1 km on the lunar rover.

At 0426 hours on 24 April the lunar module, with the astronauts aboard, was launched from the moon.

On 25 April, with "Apollo-16" about 300,000 km from earth, astronaut Mattingly walked in space. Grasping a hand rail, Mattingly moved about 5 meters across the body of the spaceship to the engine compartment. The astronaut retrieved film cassettes from the engine compartment and transferred them to the main compartment. Mattingly then removed a television camera from a bracket and placed it in the operating position, after which he returned to the cockpit. Astronaut Mattingly walked in space for 1 hour 04 minutes.

At 0933 hours Moscow time on 7 December 1972 the United States launched the last spaceship of the lunar exploration program, "Apollo-17," with astronauts E. Cernan, R. Evans and H. Schmitt.

At 2255 hours of 11 December the lunar module with astronauts Cernan and Schmitt landed on the moon. The first moon walk, which began on 12 December, lasted for about 7 hours. Cernan and Schmitt completed two more tours on the lunar surface. The astronauts used a lunar rover for moving about and completing the exploration program.

The total time of the three lunar excursions of astronauts Cernan and Schmitt exceeded 20 hours. They traveled on the lunar rover for 36 km and collected 113 kg of lunar soil specimens.

During the flight back to earth astronaut Evans did a space walk on 17 December to transfer film cassettes from the outside cameras, magnetic tape and a container with mice, which were subjected to the effects of cosmic radiation, from the engine compartment to the crew compartment.

Astronaut Evans, using a hand rail, walked along the ship to the engine compartment, retrieved everything as planned and then photographed the engine compartment. Evans' space walk lasted 45 minutes.

On 14 May 1973 the first American orbital station "Skylab" ("Sky Laboratory") was launched from Cape Kennedy by a "Saturn-5" rocket. The flight program involved the launching of three "Apollo" spaceships, each manned by three American astronauts, docking with the orbital station, boarding of it and an extended tour of duty by the people in space.

During the launch of the station into orbit aluminum panels of the meteorite shield, coated with a special film to reflect the rays of the sun, separated from the station. The temperature inside "Skylab" rose to 50°. The solar battery panels of the main unit of the station, which provided it with electricity, failed to deploy. Other malfunctions were also discovered.

On 25 May 1973 the "Apollo" with the first crew, including C. Conrad, P. Weitz and J. Kerwin, was launched. After rendezvousing with "Skylab" the astronauts boarded the station, which they were scheduled to occupy for 28 days.

The astronauts had to perform very difficult tasks in order to correct problems on the station.

C. Conrad and J. Kerwin went out into open space, cut a bolt using a rod with special cutters on the end and freed the undeployed solar battery panel. During their walk, which lasted for more than 3 hours, the astronauts repaired the panel, opened the stuck cover of one of the astronomical instruments and replaced a faulty film cassette in another instrument.

The first "Skylab" crew completed its flight after 28 days.

On 28 July 1973 the United States launched another "Apollo" with the second "Skylab" crew, consisting of A. Bean, O. Garriott and J. Lousma. They were scheduled to stay in orbit for 59 days. The flight program included medical experiments and scientific studies and a space walk. Late that evening the crew docked the "Apollo" spaceship to the station.

On 24 August astronauts J. Lousma and O. Garriott got out of the orbital station and went into outer space. According to their program they were supposed to replace film cassettes of astronomical instruments, located outside of the space laboratory, and connect the backup gyroscopes, installed in "Skylab," to the flight computer. Their work in open space lasted 4 hours 31 minutes. The astronauts spent most of the time on the installation of an additional heat shield. The second crew spent 59 days 11 hours 9 minutes in space and returned to earth on 25 September 1973.

On 16 November 1973 the third (last) crew, consisting of flight commander Gerald Carr and crew members astronaut William Pogue and scientist-astronaut Edward Gibson, was launched to the orbital station "Skylab." The flight was scheduled to last for 84 days. On 22 November W. Pogue and

E. Gibson went into space and remained there for 6 hours 34 minutes 35 seconds. During that time they repaired the drive mechanism of a radar antenna, replaced five film cassettes and placed on the surface of the station specimens of heat protective coatings for the purpose of analyzing the effect on them of cosmic rays and solar radiation. That was the longest walk by astronauts in space.

And so, during orbital flights around the earth and during return from the moon in the moon-earth transit trajectory, from March 1965 through February 1974, 19 Soviet and American astronauts walked in space.

The world's first walk in outer space by a man, accomplished by Soviet cosmonaut A. A. Leonov, can be ranked with Yu. A. Gagarin's flight in terms of its importance. If all flights by Soviet and American astronauts up until March 1965 took place in space suits and inside the cockpits of spaceships, then Leonov, clothed in a lightweight protective space suit, was the first man to meet space face to face outside the cockpit of a spaceship.

A Soviet man blazed the trail into space and was the first to step out of a spaceship into outer space.

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